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THESIS

CASE STUDY OF THE UNITED STATES MARINE CORPS ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PROGRAM TEST AND EVALUATION STRATEGY

by

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December 1999

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13. **ABSTRACT *(maximum 200 words)*** This thesis examined the evolution of the Direct Reporting Program Manager-Advanced Amphibious Assault's test and evaluation strategy from Milestone 0 to the present. The research effort involved reviewing the evolution of amphibious doctrine and amphibious vehicles, reviewing the DoD Acquisition Process and the role of T&E in that Acquisition Process, and analyzing three DRPM-AAA Test and Evaluation Master Plans. Interviews were conducted with personnel from the DRPM-AAA office and General Dynamics Amphibious Systems. Additionally, program documents and acquisition literature were reviewed. An analysis of test and evaluation issues facing the Program Management Office, a determination of the effects those issues had on the program's test strategy, and applicable lessons learned are documented for use by other major defense acquisition programs. Key research findings conclude: that the DRPM-AAA's T&E Strategy remained stable and consistent from Milestone 0 to the present as a result of the continuity of the AAAV's Key Performance Parameters; that the DRPM's decision to develop a working relationship that "actively engages" both oversight and external agencies early in the test planning process serves in achieving test resource efficiencies; and that the IPT decision-making process differs significantly from the more formal "staff planning process" used by most military organizations.

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CASE STUDY OF THE UNITED STATES MARINE CORPS ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PROGRAM TEST AND EVALUATION STRATEGY

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ABSTRACT

This thesis examined the evolution of the Direct Reporting Program Manager-Advanced Amphibious Assault's test and evaluation strategy from Milestone 0 to the present. The research effort involved reviewing the evolution of amphibious doctrine and amphibious vehicles, reviewing the DoD Acquisition Process and the role of T&E in that Acquisition Process, and analyzing three DRPM-AAA Test and Evaluation Master Plans. Interviews were conducted with personnel from the DRPM-AAA office and General Dynamics Amphibious Systems. Additionally, program documents and acquisition literature were reviewed. An analysis of test and evaluation issues facing the Program Management Office, a determination of the effects those issues had on the program's test strategy, and applicable lessons learned are documented for use by other major defense acquisition programs. Key research findings conclude: that the DRPM-AAA's T&E Strategy remained stable and consistent from Milestone 0 to the present as a result of the continuity of the AAAV's Key Performance Parameters; that the DRPM's decision to develop a working relationship that "actively engages" both oversight and external agencies early in the test planning process serves in achieving test resource efficiencies; and that the IPT decision-making process differs significantly from the more formal "staff planning process" used by most military organizations.

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I. INTRODUCTION

A. PURPOSE

The purpose of this research is to examine the evolution of the AAAV Program Management Office's test and evaluation strategy from Milestone 0 to the present. The goal is to analyze the critical test and evaluation issues facing the Program Management Office, analyze the effect of those issues on the program's test strategy, and to develop applicable lessons learned for other major defense acquisition programs.

B. BACKGROUND

Recent changes in the focus of naval and amphibious warfare have resulted in a need for both the Navy and Marine Corps to conduct their operations from over-the-horizon (OTH). This evolution in amphibious warfare doctrine is based on a triad of surface and air delivery platforms capable of getting Marines and their equipment from ship-to-shore in a more rapid and less vulnerable way [Ref. 1]. Existing Marine Corps Assault Amphibian Vehicles (AAVs) do not meet the needs of this developing over-the-horizon doctrine. [Ref. 2:p. 6] An Advanced Amphibious Assault Vehicle program to meet this need was initiated, canceled, and restarted several times in the mid and late 1980's before a Program Management Office was finally established in June of 1990. [Ref. 3:p. 2]

As the primary ground combat acquisition program in the Marine Corps, the AAAV faces much scrutiny from different Department of Defense (DoD) organizations and the United States Congress. In fact, Congressional involvement in major defense acquisition programs (MDAPs) has increased significantly over the past decade as they have sought ways to improve the effectiveness of the DoD Acquisition Process. [Ref. 4:p. 21] One area of the acquisition process that is probably the most visible, and therefore receives the greatest scrutiny is the test and evaluation process of a major defense acquisition program. Congress has mandated that it receive a Live-Fire Test and Evaluation Report and a Beyond Low-Rate Initial Production (LRIP) Report indicating a program's readiness to proceed into full rate production prior to approval to do so. [Ref. 5:part 3.4] In order for a Program Manager to successfully develop a system capable of meeting the user's operational requirements, he must establish a test and evaluation strategy that tracks the system's capabilities and performance throughout the entire acquisition cycle.

Previous studies of the AAAV PMO have indicated that it has successfully made critical decisions concerning acquisition reform measures to reduce the risk of cost and schedule overruns, and ineffective performance. [Ref. 3, 6, 7] These studies also indicate that the PMO was forward thinking in its overall acquisition strategy by streamlining the contractor / government relationship, increasing the use of Integrated Product Process Development (IPPD) and Integrated Product Teams (IPTs), and adopting commercial business practices. [Ref. 3] One study in particular praised the PMO for its risk management and mitigation methodology, yet indirectly questions the PMO for its use of a "classical" test and evaluation approach in an otherwise "evolutionary" acquisition strategy. The study recommended further research into the issues, feasibility, advantages, and disadvantages associated with a "classical" T&E approach in an "evolutionary" acquisition strategy. [Ref. 6:p. 79]

This thesis, therefore, will examine the evolution of the AAAV Program Management Office's test and evaluation strategy from Milestone 0 to the present. The goal is to analyze the critical test and evaluation issues facing the Program Management Office, analyze the effect of those issues on the program's test strategy, and to develop applicable lessons for other major defense acquisition programs.

C. RESEARCH QUESTIONS

1. Primary

The primary research questions that this thesis will address are: How has the AAAV test and evaluation strategy evolved from Milestone 0 to the present, and what lessons learned can be derived from this evolution?

2. Subsidiary

The subsidiary research questions are as follows:

- What test and evaluation related issues have been faced, and what decisions have been made with respect to AAAV test and evaluation?
- What is the AAAV Developmental Test and Evaluation (DT&E) strategy?
- What is the AAAV Operational Test and Evaluation (OT&E) strategy?
- What impact has the implementation of Acquisition Reform measures had on the AAAV test and evaluation process?
- Will an analysis of AAAV T&E strategy be useful in the development of future MDAP T&E strategies?

D. SCOPE AND LIMITATIONS

The scope of this thesis will be a case study of the evolution of the AAAV PMO's test and evaluation strategy. The study will review standard test and evaluation practices; the contractor's test and evaluation practices; and, the test and evaluation practices as developed by the AAAV PMO. The study will then analyze specific test and evaluation issues effecting the PMO; review the decisions made and strategy developed by the PMO; and finally, develop lessons learned that may be applicable to other major defense acquisition programs.

The study will not conduct a critique or evaluation of the overall acquisition strategy, nor an analysis of detailed test plans for individual components of the AAAV (turret, software, engine, etc.).

E. METHODOLOGY

The methodology used in this thesis research consists of the following: (1) conduct a literature search of books, magazine articles, CD-ROM systems, and other library information resources, (2) conduct a review of all program test and evaluation related documents, (3) interview personnel from the PMO, General Dynamic Amphibious Systems (GDAMS), Marine Corps Operational Test and Evaluation Activity (MCOTEA), and Marine Corps Systems Command (MARCORSYSCOM), and (4) conduct a site visit to the PMO/GDAMS facility to discuss test and evaluation issues.

F. ORGANIZATION OF STUDY

Chapter I. Introduction. Identifies the focus and purpose of the thesis and states the primary and subsidiary research questions.

Chapter II. Assault Amphibian History. This chapter provides the reader with an overview of assault amphibian doctrine and history.

Chapter III. Department of Defense Acquisition Overview. This chapter provides the reader with an extensive overview of Department of Defense Acquisition Process.

Chapter IV. Department of Defense Test and Evaluation Overview. This chapter provides an overview of the types of test and evaluation in the DoD, the test and evaluation process as it relates to the acquisition process, and an overview of previous lessons learned from both a developmental and operational test perspective.

Chapter V. AAAV Test and Evaluation Strategy. This chapter outlines the PMO's acquisition strategy, test and evaluation strategy, and the process used to reconcile the established operational requirements necessary for testing purposes.

Chapter VI. Test and Evaluation Related Issues and Lessons Learned. This chapter analyzes the test and evaluation related issues facing the Program Management Office, assesses the effect of those issues on the program's test strategy, and develops applicable lessons for other major defense acquisition programs.

Chapter VII. Conclusions and Recommendations. The final chapter summarizes the findings of the research, summarizes the lessons learned, provides recommendations from this study, and provides recommendations for future research.

G. CHAPTER SUMMARY

This chapter has identified the focus and purpose of the thesis, stated the primary and subsidiary research questions, addressed the scope of the thesis, and familiarized the reader with the organization of the study. The next three chapters will provide the reader the necessary background to place the remainder of the thesis and its analysis in context.

II. ASSAULT AMPHIBIAN HISTORY

A. INTRODUCTION

The United States Marine Corps' quest for an Advanced Amphibious Assault Vehicle is a classic example of the dynamic relationship between the military operating environment, doctrine, and technology. The relationship between the three is generally cyclic and evolutionary. As a change in technology occurs, one must modify or develop a new doctrine to successfully apply that technology. This new doctrine then creates a new environment in which the military must operate. The AAAV is the forth generation of amphibian vehicles resulting from the Marine Corps' application of this environment-doctrine-technology cycle.

This chapter examines the evolution of amphibious doctrine from its founding in the early 1930's, to the development of today's Over-The-Horizon concepts. The chapter will then examine the evolution of the first three generations of amphibian vehicles designed to meet changing Marine Corps doctrine with improved technology.

B. AMPHIBIOUS DOCTRINE

As an element of the Naval Service, the Marine Corps has a tradition of operating at sea and ashore, thus its amphibious nature. Therefore, an amphibious operation can be defined as, "an attack launched from the sea by naval and landing forces, embarked in ships or craft involving a landing on a hostile or potentially hostile shore." [Ref. 8]

Amphibious doctrine first evolved in the early 1920's and 1930's when the United States realized that there was a strong likely-hood of a conflict with Japan in the Pacific.

The Marine Corps worked extensively on developing amphibious landing techniques that would meet the challenges of an island-hopping campaign designed to secure advanced naval and air bases in that region. In 1934, the Tentative Manual for Landing Operations (LFM 0-1) was published. [Ref. 9:p. 34] Though refined in its detail from experiences gained in World War II, Richard S. Moore stated in 1985 that, "[The] current amphibious doctrine, embodied in LFM 0-1...reflects the past 50 years of development. It differs little from the 1934 manual." [Ref. 9:p. 34] Moore questioned the viability of existing doctrine in the face of changing threat technology.

> The proliferation of missile weapons and the potential for the smallest of armies to obtain nuclear weapons increase the vulnerability of an amphibious landing. That landing's survivability rests with the doctrine with which it is executed. [Ref. 9:p. 32]

Moore concludes that, "If future amphibious landings are to avoid disaster, there must be a resurgence in the doctrinal thought of the 1930's." [Ref. 9:p. 36]

In 1986, the Commandant of the Marine Corps, General P. X. Kelley, published his vision of Amphibious Warfare Strategy as it related to the National Military Strategy. General Kelley has three main points to his strategy. First, he reaffirmed the Marine Corps' responsibility as the lead service in developing amphibious tactics, techniques, and equipment as outlined in the National Security Act of 1947. [Ref. 10:p. 23]

Second, General Kelley describes the world environment in which the Marine Corps will operate over the next decade. This environment includes a reduction in overseas basing that increases the significance of amphibious forces. Specifically, "Amphibious forces, on the other hand, can be stationed over the horizon at sea, need no basing or overflight clearances, and provide their own sustainment." [Ref. 10:p. 25] By defining the world environment as such, and by defining the role of amphibious forces, General Kelley ensured the importance of an amphibious forcible entry capability in the overall national strategy.

General Kelley's final point is that the Navy and Marine Corps must act as an amphibious team to maximize each other's military capabilities. Two of the pillars of this teamwork concept are equipment and doctrine. With respect to equipment, General Kelley identifies the acquisition of the Landing Craft Air Cushion (LCAC) and the MV-22 tilt-rotor aircraft (Osprey) as significant. He says, "These platforms will allow for a much more rapid closure to the beach, giving the amphibious task force the option of operating from over the horizon, out of range of many enemy weapon systems." [Ref. 10:p. 27-29] With respect to doctrine, General Kelley concludes, "We believe that there is ample evidence to suggest that we have entered a renaissance period in the evolution of amphibious operations, with the broadening of our vistas through the introduction of the LCAC and Osprey yet to come." [Ref. 10:p. 29]

The demise of the Soviet Union and the end of the Cold War brought about a renaissance in not only amphibious strategy, but also the overall maritime strategy. In September 1992, the Secretary of the Navy, Chief of Naval Operations, and the Commandant of the Marine Corps published their vision of how to meet this significant shift in the military operating environment. The White Paper, "...From the Sea: A New Direction for the Naval Services", identifies this new operating environment, explains the naval services role in this environment, and assigns tasks to carry out that role. [Ref. 11:pp. 18-22]

The new direction for the naval services "represents a significant shift away from open-ocean warfighting on the sea toward joint operations conducted from the sea." [Ref. 11:p. 19] Operating from the sea means operating in the near land, or littoral, areas of the world in an environment that poses varying technical and tactical challenges to naval forces. [Ref. 11:p. 20] The naval services' role in the littoral region will be met by providing strong naval expeditionary forces, specifically tailored and capable of projecting power ashore.

The white paper assigns 15 tasks to the Navy and Marine Corps in order to achieve this new vision of maneuvering from the sea. Of the 15, the following three indirectly contribute to the Marine Corps' justification for the AAAV [Ref. 11:p. 22]:

- Develop naval doctrine consistent with new direction and focus-including an examination of functions and capabilities.

- Increase emphasis on generation of high-intensity power projection, support of forces ashore, and weapons necessary to fulfill the mission.

- Procure equipment systems to support this strategy and remain ahead of the global technology revolution in military systems.

In 1994, the Secretary of the Navy, Chief of Naval Operations, and the Commandant of the Marine Corps published "Forward...From the Sea." This white paper, "updates and expands the strategic concept to address specifically the unique contributions of naval expeditionary forces in peacetime operations, responding to crises, and in regional conflicts." [Ref. 12:pp. 32-35] "Forward...From the Sea" reaffirms the direction of evolving strategy, confirms the need for naval expeditionary forces, and establishes projection of power from sea to land as the number one prevailing role for naval forces. [Ref. 12:p. 35]

On 4 January 1996, the Commandant of the Marine Corps, General C. C. Krulak, approved the Marine Corps' contribution to this evolving doctrine by releasing "Operational Maneuver From the Sea: A Concept for the Projection of Naval Power Ashore." [Ref. 13:p. A1-A6] General Krulak indicates that Operational Maneuver from the Sea (OMFTS) results from two changes in the operational environment. First, a new series of threats is resulting from national aspirations, religious intolerance, and ethnic hatred in the littoral region. Second, opportunities from enhancements in information management, battlefield mobility, and conventional weapons' lethality will allow for increased Marine Corps capabilities. [Ref. 13:p. A-1]

The concept paper states:

> What distinguishes OMFTS from all other species of operational maneuver is the extensive use of the sea as a means of gaining advantage, an avenue for friendly movement that is simultaneously a barrier to the enemy and a means of avoiding disadvantageous engagements. This aspect of OMFTS may make use of...the sea as a medium for tactical and operational movement. [Ref. 13:p. A-3]

The concept paper further asserts that, "landing forces armed with the tactical mobility and fire support capabilities of the present will be hard pressed to decisively engage an enemy who is likely to combine the destructive capabilities of a conventional force with the elusiveness of a guerrilla." [Ref. 13:p. A-3] With additional references to "modernizing our capabilities" and the need to "overcome challenges in the areas of battlefield mobility", OMFTS firmly identifies the deficiencies of existing amphibious vehicles, and establishes the justification for advanced amphibian assault capabilities without specifically identifying the AAAV by name. [Ref. 13:p. A-5]

The evolution of amphibious doctrine, from a surface assault perspective, flourished in the 1930's, solidified in the 1940's, and then languished for nearly 40 years. Only in the last ten years has amphibious doctrine been revitalized by a significant shift in the operational environment. As will be seen next, this evolving doctrine drove new equipment requirements for its support.

C. EVOLUTION OF ASSAULT AMPHIBIAN VEHICLES

As the doctrine for amphibious warfare evolved over the past 70 years, so did the equipment required to support that doctrine. In the late 1920's and early 1930's, the Navy and the Marine Corps conducted several amphibious exercises in Hawaii, the Caribbean, and Quantico, Virginia. [Ref. 14] The results of these exercises concluded that existing landing craft, though successful in transporting troops and limited equipment from ship to shore, lacked the capability to cross coral reefs that surrounded many Pacific Islands. Additionally, the landing craft did not allow Marines to push equipment and supplies forward off the exposed beach and out of enemy direct fire range. [Ref. 3:pp. 15-16]

Some initial tests were conducted on the Christie Amphibious Tank in 1924 and again on the British Vicker-Armstrong Light Amphibious Tank in 1932. Both designs were rejected because of their questionable seaworthiness, and their slow water speeds.

[Ref. 15:pp. 17-33] The original focus on these new vehicles was for a modified tank to become amphibious in nature. This would provide the first wave ashore the capability to fill a fire support gap between naval gunfire and close air support. [Ref. 16:p. 8] The Marine Corps soon realized that it must coordinate its search for better equipment, and in late 1933 the Marine Corps Equipment Board was established in Quantico, Virginia. The board's purpose was to test and develop material for landing operations and expeditionary service. [Ref. 14]

In 1937, a Navy Admiral passed to the Commandant of the Marine Corps a copy of Life Magazine that contained an article titled, "Roebling's Alligator for Florida Rescue." The article described Donald Roebling's development of a tracked amphibious vehicle designed for, "...transporting victims through the swamps, over drowned roads, [and] across debris filled bayous." [Ref. 15:p. 34] The Commandant directed the Equipment Board to review the "Alligator" for potential as a military vehicle. After two years of review, test, and evaluation, Army, Navy, and Marine Corps officials were so impressed that Food and Machinery Corporation (FMC) was contracted to build a modified Roebling vehicle for full-scale production. The first Landing Vehicle Tracked (LVT(1)) came off the assembly line in July 1941, and the 1st Amphibian Tractor (AmTrac) Battalion of the 1st Marine Division was fully operational by 16 February 1942. [Ref. 15:pp. 34-42]

The LVT(1) was strictly a cargo variant amphibian armed with a .50 and .30 caliber machine gun for self-protection. The Marine Corps, however, continued its pursuit of an armored version of the LVT that would have a turret with a 37-mm gun. [Ref. 16:p. 8] The LVT(1) soon found itself in combat in WWII during operations in Guadalcanal. The vehicle proved its versatility as a cargo handler by shuttling supplies from ship to shore, transporting wounded Marines, providing protective fires, towing artillery into position, and assisting in the installation of a bridge. [Ref. 16:p. 9] During this period in the United States, the Marine Corps developed an improved cargo variant known as the LVT(2), or "Water Buffalo". It also designed and produced an armored version of the LVT(2) designated the LVT(A)2, and a turreted version of the LVT(A)2 known as the LVT(A)1. [Ref. 16:p. 9]

Despite only having the LVT(1) and the LVT(2) during the battle for Tarawa, the 2nd Marine Division would not have been successful without out them. The significant lesson from that battle was, "The need for more LVTs with better armor and an armored fire support variant..." [Ref. 16:p. 10] The Marine Corps was convinced of the value of the LVT for its campaign in the Central Pacific, and was sure that, "No other vehicle could offer protection and mobility in heavy surf with full loads of men and equipment and rapidly transition from water to land operations." [Ref. 16:p. 9] Figure 1 shows a LVT(2) in the foreground and a LVT (1) (Number 49) following the battle of Tarawa.

Figure 1. LVT(1) and LVT(2) ashore at Tarawa. [Ref. 38:p. 17]

As the war progressed, the lessons from combat in the Marshall Islands indicated the need for troop carrying LVTs with a cargo ramp and better bilge pumps for discharging water. The need for an armored variant with greater firepower than the 37mm was also determined. FMC developed and produced the LVT(3) and the LVT(4) with a ramp for easier loading and unloading of personnel, equipment, and supplies. FMC also developed and produced the LVT(A)4 armed with a 75mm howitzer assault gun and later the LVT(A)5 with a gyro-stabilized 75mm howitzer. These variants were used for direct fire missions upon landing, and then provided indirect fire once ashore. [Ref. 16:p. 11] Figure 2 shows LVT(A)4s as they move toward shore in the battle of Okinawa.

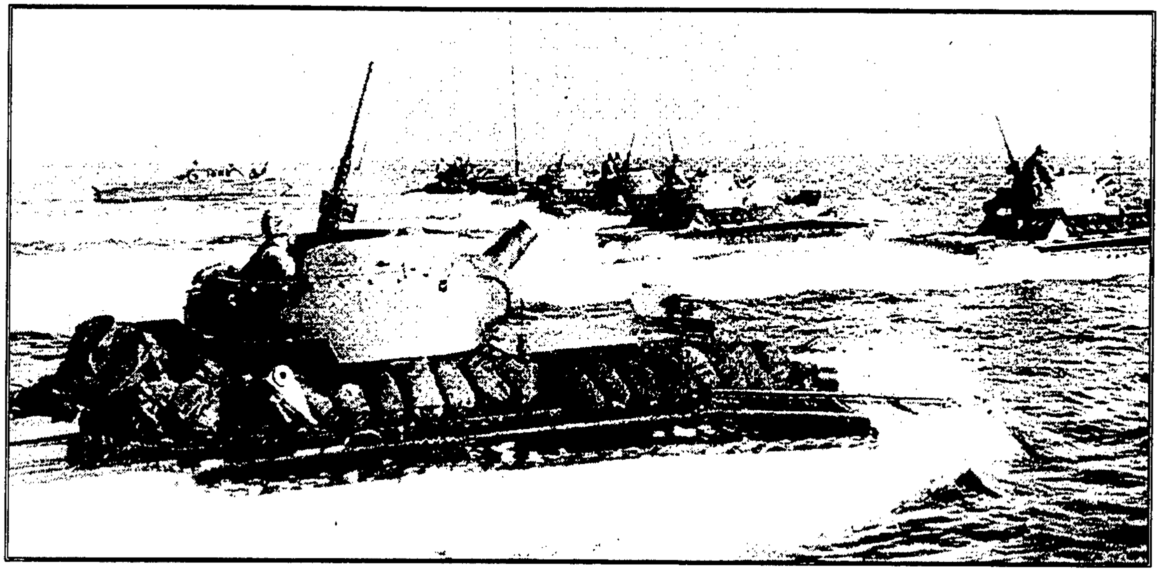

Figure 2. LVT(A)4s move toward shore at Okinawa in 1945. [Ref. 39:p. 14]

By the war's end in 1945, the Marine Corps had grown from the 1st Amphibious Tractor Battalion to, "...three armored amphibian battalions equipped with the LVT(A)4 and nine cargo amtrac battalions equipped with LVT(3)s or LVT(4)s." [Ref. 17:p. 71] With the surrender of Japan, "...LVT production that over the preceding 4 years had delivered 18,816 amphibian tractors of all models..." came to an end. [Ref. 17:p. 71]

In 1948, 1200 LVT(3)s underwent modification. The cargo area was covered by folding metal doors to shield passengers from enemy grenades, and from breaking seawater. Additionally, a machine gun cupola was mounted top-center and forward near the bow. [Ref. 15:p. 248] The resulting LVT(3)C variant and the LVT(A)5 variant:

> ...bore the brunt of fighting in Korea, functioning more in the role of an armored personnel carrier on land than an amphibious vehicle in water-borne landings because the Korean struggle used the United States Marine Corps as much for its infantry power as for its amphibious capability. Instead of short, sharp fights for islands, the Corps operated nearly

continuously on land on the Korean Peninsula, requiring the LVT to assist more overland than over water. [Ref. 15:p. 248]

The link between the changing operational environment of the LVT in Korea and changing requirements for a new LVT was established with the production of the LVT(5) family of vehicles in 1953. The LVT(5) was a significant departure in design from previous WWII variants of the LVT. Much larger in size, and capable of carrying 30-34 combat loaded Marines, the LVT(P)5 nearly doubled the LVT(3)'s personnel capacity. [Ref. 16:p. 13]

The LVT(5) family of vehicles represented the second major generation of LVTs and consisted of special variants each with its own mission. The LVT(P)5 was a personnel and cargo carrier. The LVT(C)5 was a command and control vehicle specially designed as a mobile command post during amphibious landings and operations ashore. The LVT(R)1 was a recovery and maintenance vehicle with winches, a crane, a welding rig, and special maintenance equipment. The LVT(E)1 was an combat engineer variant designed for minefield breaching. This vehicle had a large mine plow on the front, and a rocket-propelled line charge inside. When deployed and detonated, the line charge would clear a 350-foot long lane through a minefield by sympathetically detonate the buried mines. Finally, the LVT(H)6 was a fire support vehicle with a specially designed turret containing a 105mm howitzer. [Ref. 15:pp. 248-254] Figure 3 shows a LVT(R)1 with its crane in the extended position.

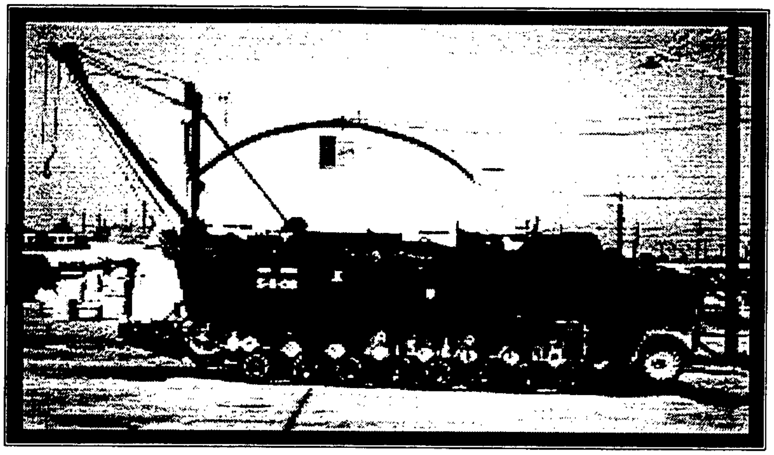

Figure 3. LVT(R)1 with crane in extended position.

The LVT(5) family of vehicles saw extensive action in Vietnam. They carried out amphibious landings, fire support missions, resupply missions, mechanized patrolling, and medical evacuations. Combat use of the LVT(5) exposed several deficiencies including flammable gas tanks in the vehicle's bottom deck, fuel and hydraulic leaks, low water speed and maneuverability, and failing parts. [Ref. 15:p. 255] Combined with its 20-year age, these deficiencies eventually drove the Marine Corps to seek a new series of LVTs. [Ref. 16: p. 14]

The LVT(7) family of vehicles constitutes the third and present major generation of LVTs, and represents yet another radical departure in design. The vehicle was designed to optimize its speed in the water through the use of water jet propulsion units, and through an angled front-hull shape to reduce drag. This design gave the vehicle greater buoyancy and increased maneuverability in the water, and was based on the original operational requirement to operate 80 percent of the time in the water and 20 percent of the time on land. [Ref. 16:p.14] Previous LVTs were propelled through the water simply by having the specially designed tracks continue to turn, pushing the vehicle forward. [Ref. 16:p. 14] Table 1 shows a comparison of the dimensions and speeds of the LVT(3), LVT(P)5, and the LVT(P)7. The LVT(7) family of vehicles is much smaller than the LVT(5) family and only consists of the personnel LVT(P)7, command and control LVT(C)7, and recovery LVT(R)7 variants.

Characteristics	**LVT(3)**	**LVT(P)5**	**LVT(P)7**
Length	24' 6"	29' 8"	26'
Width	11' 2"	11' 8.5"	10' 3.75"
Height (top of vehicle)	9' 11"	8' 7.5"	9' 9"
Weight (Empty)	26,600 lbs.	69,780 lbs.	40,000 lbs.
Cargo Capacity	12,000 lbs.	12,000 lbs. (water) 18,000 lbs. (land)	10,000 lbs.
Speed, Water	6 mph	6.8 mph	8.4 mph
Speed, Land	17 mph	30 mph	40 mph
Engine	Cadillac V-8 (2) each 220HP	Continental V-12 (1) 810 HP	Detroit Diesel 400 HP

Table 1. LVT(3), LVT(P)5, and LVT(P)7 comparison. [Ref. 15:pp. 254,256]

The Marine Corps increased its training in combined arms and desert warfare during the late 1970's and 1980's at the Marine Corps Air Ground Combat Center, Twenty Nine Palms, California. These Combined Arms Exercises (CAX) gradually shifted the role of the LVT(7) toward that of an armored personnel carrier. The exercises showed that the Marines needed improvements in the LVT(7)'s survivability. [Ref. 16:p. 14] The shift toward mechanized operations changed the operational ratios of the LVT(7) to 20 percent waterborne operations and 80 percent land operations. [Ref. 19: p. 2]

The planned service life of the LVT(7) vehicle was ten years. However, since no replacement existed, the Marine Corps began a Service Life Extension Program (SLEP) in 1983 to ensure operability through 1994. [Ref. 3:p. 20] In addition to modernizing 853 LVT(P)7s, 77 LVT(C)7s, and 54 LVT(R)7s, the Marine Corps acquired 333 of the newly designated LVT7A1 vehicles. [Ref. 17:p. 76] The SLEP involved converting the turret from hydraulic power to electrical power, and replacing the Detroit Diesel engine with a newer and more powerful V-8 turbocharged Cummins Diesel engine. Other modifications involved changes to the fuel tanks, suspension, and communications. Soon after the completion of the SLEP, the vehicle was redesignated the AAV7A1 family. [Ref. 16:p. 14]

The December 1991 issue of the Marine Corps Gazette describes the next series of vehicle modifications and improvements as follows:

> Beginning in 1987, a series of product improvements and a rotating inspection cycle were initiated and have pushed the life expectancy well into the next decade when a replacement system is expected to be fielded. The product improvement program (PIP) combines a number of initiatives to enhance vehicle mobility, firepower, and survivability. These initiatives, broken into three separate blocks, are being phased in gradually over a number of years. [Ref. 18:p. 4]

The Block 1 upgrades consist of [Ref. 18:p. 4]:

- Replacing the electric drive weapons station and its M-85 .50 Cal machine gun with an Upgunned Weapons Station with a Mk-19 40mm machine gun and a M2HB .50 Cal heavy machine gun.

- Adding P-900 applique armor to the sides of the AAV to give the vehicle protection from incoming rounds by interrupting and diverting their flight path.

- Adding a rotary bow plane kit to the front of the vehicle to aid in waterborne mobility by enhancing trim.

The Block 2 upgrades consist of [Ref. 18:p. 4]:

- Adding an automatic fire-sensing and suppression system capable of extinguishing flames within microseconds.

- Replacing the P-900 armor with Enhanced Armor Applique Kits (EAAK). EAAK covers more surface area and provides a greater protection from incoming rounds than does the P-900.

- Minor modifications to the suspension and upgrades to the transmission.

The Block 3 upgrades described in the Marine Corps Gazette never materialized as envisioned but evolved into the Reliability, Availability Maintainability/Rebuild to Standard (RAM/RS) program. The addition of the turret, armor, and bow plane resulted in an increase of weight for the AAVP7A1 from 40,000 pounds to 61,300 pounds fully loaded. [Ref. 20:p. 1] The detailed test plan for the AAV RAM/RS states, "The increased weight has resulted in a reduced horsepower to weight ratio, increased maintenance costs on the suspension, limited supply support, and decreased performance." [Ref. 20:p. 1] This degradation of performance made the AAV7A1 unable to perform to its original specifications. Additionally, Marine Corps attempts to maintain the AAV's readiness through the Inspect and Repair Only as Necessary (IROAN) program became prohibitively costly. [Ref. 20:p. 1] Figure 4 shows an AAVP7A1 with Block 1 and Block 2 upgrades including Upgunned Weapon Station, Enhanced Applique Armor Kit (EAAK), and bow plane.

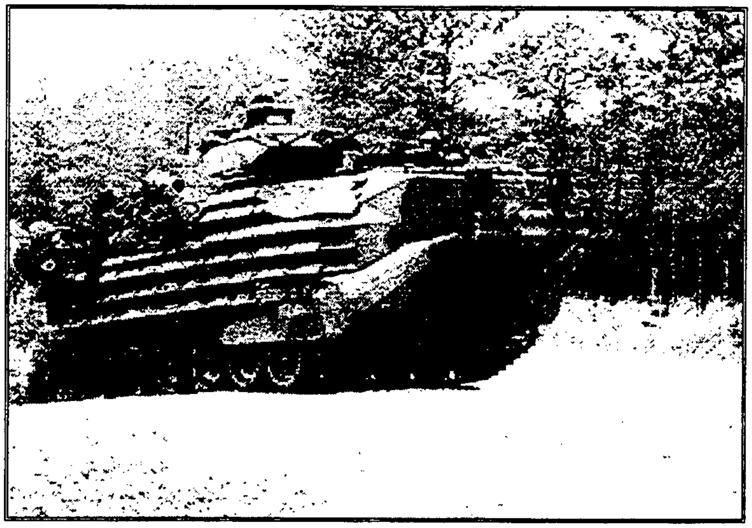

Figure 4. AAVP7A1 with Upgunned Weapons Station, EAAK, and Bow Plane.

The AAV7A1 RAM/RS will undergo significant modifications to the hull in order to accommodate a new suspension system and new engine, both derivatives of the U. S. Army's M2 Bradley Fighting Vehicle. The new suspension will raise the present ground clearance of 12 inches back to the original 16 inches. A Cummins Model VT903-525 horsepower engine will replace the current 400 horsepower engine, thus regaining the 17 to 1 horsepower to ton ratio. [Ref. 19:p. 3] The detailed test plan further states,

> The AAV7A1 RAM/RS will enable the vehicle to operate at or near its original performance specifications and allow it to better perform its assigned missions indicated in the original Required Operational Capability (ROC) document. These improvements will provide a more reliable and less costly platform which will allow the AAV7A1 to continue as the primary tactical ground mobility asset for the Marine Corps until the introduction of the new Advanced Amphibious Assault Vehicle. (AAAV). [Ref. 20:p. 1]

The mission of the AAV7A1 family of vehicles remains, "...to land the surface elements of the landing force and their equipment in a single lift from assault shipping during amphibious operations to inland objectives and to conduct mechanized operations and related combat support in subsequent operations ashore." [Ref. 19:p. 1] However, even with the RAM/RS upgrades, the AAV7A1 family of vehicles remains deficient in meeting the needs of the Marine Corps as it moves toward implementing the Operational Maneuver From The Sea (OMFTS) doctrine.

The Operational Requirements Document (ORD) for the Advanced Amphibian Assault Vehicle (AAAV) (No. MOB 22.1) specifically states, "The deficiencies and design constraints of the AAV7A1 render it unsuitable for the execution of '...From the Sea' and OMFTS amphibious operations in the year 2005 and beyond." [Ref. 2:p. 9] A draft copy of the System Concept Paper (SCP) for the Advanced Amphibious Assault (AAA) program indicates that these deficiencies were tentatively identified in the Mission Area Analysis of Mission Area 232.3, Ship to Shore Movement (Secret NOFORN) dated 24 August 1987. [Ref. 21:Encl. 1] The Draft SCP goes on to state that, "Significant shortfalls in land and sea mobility, speed, and agility along with serious deficiencies in offensive firepower (lethality) and inherent armor protection levels (survivability), have been confirmed through force-on-force analysis using DIA [Defense Intelligence Agency] validated threat projections." [Ref. 21:Encl. 1]

The original AAAV ORD identifies 11 major deficiencies with respect to the operational capabilities and survivability of the AAV7A1. They are as follows: [Ref. 2:pp. 10-11]

- Water Mobility. The AAV7A1 possesses inadequate water speed to support the "From the Sea" and OMFTS concepts.

- Firepower

  - The AAVP7A1 does not have a weapon system with sufficient lethality to defeat light armored combat vehicles (BTR, BRDM, BMP) projected for the 2005-2025 time frame.

  - The AAVP7A1 does not have a system that enables the gunner/vehicle commander to sight his weapons system during reduced light conditions or through battlefield obscurants (e.g., smoke) to the effective range of weapons.

  - The weapon systems in the AAVP7A1 are not stabilized to allow accurate employment of the weapons against stationary and moving enemy targets while the vehicle is moving on land and in the water.

- Armor Protection

  - The AAV7A1 has minimal integral hull side armor protection against 7.62mm Armor Piercing (AP) munitions fired at greater than 300 meters (1000 feet) and overhead protection from 105mm artillery bursts 15 meters (50 feet) from the vehicle.

  - The AAV7A1 can only achieve 14.5mm armor protection on the sides at 300 meters and overhead protection against, for the troop compartment, 152mm artillery fragments at 15 meters from the vehicle with the application of bolt-on armor which adds 2040 kg (4500 lbs) to overall vehicle weight and is time consuming to install. Additionally, the added weight reduces mobility, produces a negative effect on the suspension, and adversely effects the power train and suspension life.

  - The AAV7A1 possesses inadequate armor protection against chemical energy weapons (e.g., RPG).

- Land Mobility. The AAV7A1 lacks the mobility to operate with the M-1A1 main battle tank.

- Signature. The AAV7A1 family of vehicles possess significant adverse visual, aural, magnetic, infrared, and electromagnetic signatures.

- Fire Prevention / Suppression. The AAV7A1 does not have a multi-incident fire suppressive capability that protects the crew and embarked personnel against catastrophic fires resulting from ignition of the fuel or fuel cell by munitions or incendiary rounds penetrating the vehicle hull.

- Directed Energy. The AAV7A1 lacks directed energy countermeasures to protect against directed energy weapons.

- NBC Protection

  - The AAVP7A1 does not possess a collective protection system that will allow the crew and embarked personnel to survive in NBC [Nuclear, Biological, Chemical] environments.

  - The AAV7A1 does not have a NBC detection or monitoring capability.

  - The present level of nuclear hardening protection in the AAV7A1's electrical and electronic equipment will not protect equipment from the current threat capability.

- Night Driving. The driver's station of the AAV7A1 does not provide the driver with the capability to see through obscurants or operate at high speeds in adverse weather or at night.

- Anti-Tank Guided Missile (ATGM) Countermeasure. The AAV7A1 does not possess a countermeasure capability to defeat ATGM guided systems.

- Current Operational Deficiencies of the AAVC7A1

  - Accurate and continuous location of friendly forces is not available.

  - The vehicle has inadequate ventilation for heat generated by communications equipment.

  - Communications equipment fails due to exposure to the amphibious (salt-water) environment.

  - The current AAVC7A1 does not meet all the net requirements of the supported unit.

The above listed deficiencies in the AAV7A1 family of vehicles establish the requisite capabilities of the next generation of amphibious vehicles, the AAAV. Further more, the requisite capabilities will establish a benchmark from which the new vehicle will be tested.

D. CHAPTER SUMMARY

This chapter examined the evolution of amphibious doctrine and the evolution of the amphibious vehicles that met the needs of that doctrine. The chapter serves as a foundation for understanding the Marine Corps' stated requirement for the AAAV. The following chapter describes the DoD's acquisition process.

III. DEPARTMENT OF DEFENSE ACQUISITION OVERVIEW

A. INTRODUCTION

This chapter provides the reader with an overview of the Department of Defenses' (DoD's) acquisition system, and recent acquisition reform efforts. It will cover the DoD 5000 Series of directives and instructions, key individuals and forums in the acquisition process, the requirements generation process, and the acquisition management process. The chapter will address these concepts from the major defense acquisition program (MDAP) level, specifically for Acquisition Category I(D) (ACAT I(D)) programs, as this is the category for the AAAV.

B. DOD ACQUISITION SYSTEM AND ACQUISITION REFORM

The defense acquisition system, "is a single uniform system whereby all equipment, facilities, and services are planned, developed, acquired, maintained, and disposed of by the Department of Defense (DoD)." [Ref. 22:p. 1] The system provides the DoD a standardized framework for the acquisition of weapon systems that allow the DoD to meet and conduct its mission. This system is greatly influenced by the Executive Branch that sets policy, the Legislative Branch that controls funding and legislation, and the Defense Industry that ultimately produces weapon systems. Often these three elements create an environment of significant, diverse and competing interests. [Ref. 22:pp. 1-5] The ultimate goal of the defense acquisition system is to, "...acquire quality products that satisfy the needs of the operational user with measurable improvements to mission accomplishment, in a timely manner, at a fair and reasonable price." [Ref. 23:p. 3]

Defense systems acquisition get its authority from a multitude of statutes, executive directions, Office of Management and Budget (OMB) Circular A-109, and the Federal Acquisition Regulation (FAR). Congressional dissatisfaction with DoD acquisition procedures has resulted in a number of initiatives and legislation to reform the overall acquisition process. Most significant of these were the 1991 Department of Defense Authorization Act, the 1994 Federal Acquisition Streamlining Act (FASA), and the 1996 National Defense Authorization Act. The basic intent of these acts was to simplify the procurement procedures and to restructure the DoD acquisition organization and workforce. [Ref. 22:pp. 11-13]

C. DOD 5000 SERIES

One of the measures taken to simplify the procurement procedures was the consolidation of numerous DoD acquisition directives and instructions into a new DoD 5000 Series. The provisions of OMB A-109 were implemented in March of 1996 in two primary documents, DoD Directive 5000.1, Defense Acquisition and DoD Regulation 5000.2-R, Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs. [Ref. 22:p. 15]

DoD 5000.1 identifies three broad policy principles applicable to all defense acquisition programs, three primary decision support processes, and key acquisition individuals. The three principles are: [Ref. 23:pp. 4-7]

- Translating operational needs into stable, affordable programs.
- Acquiring Quality Products.
- Organizing for Efficiency and Effectiveness.

One of the elements of the first principle is to provide for an integrated management framework. The three primary decision support processes form this management framework. Those three processes are: [Ref. 23:p. 4]

- Requirements Generation Process.
- Acquisition Management Process.
- Planning, Programming, and Budgeting Process.

As can be seen in Figure 5, the three processes are overlapping and related.

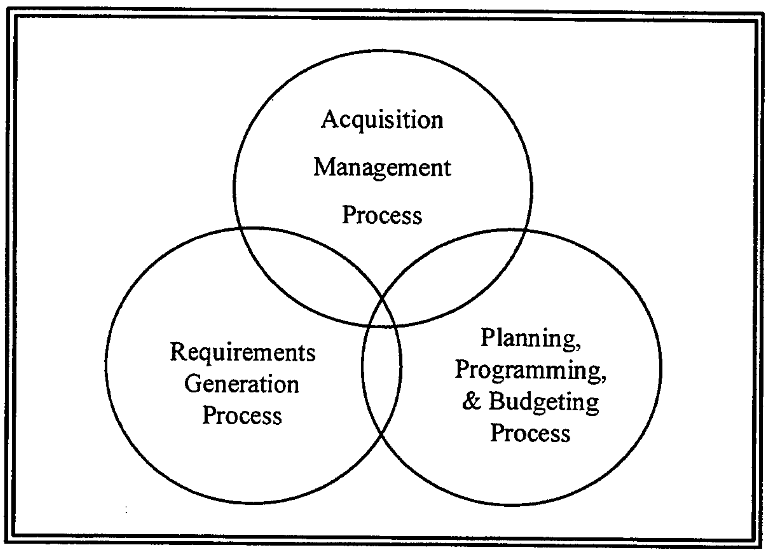

Figure 5. DoD's Three Decision Support Processes. [Ref. 22:p. 16]

Following an introduction to key individuals and key acquisition forums, the requirements generation process and acquisition management process will be covered. Test and evaluation generally falls into the overlap area of these two processes.

D. KEY ACQUISITION INDIVIDUALS AND FORUMS

DoD 5000.1 describes a key official as, "...a DoD official who is: a member of the streamlined acquisition chain of command or a member of the Defense Acquisition Board." [Ref. 23] A forum is a group of key officials responsible for acquisition related decisions. This section briefly describes the responsibilities of key acquisition officials and forums pertinent to a Marine Corps MDAP-level program.

1. Deputy Secretary of Defense

The Deputy Secretary of Defense approves funding for new acquisition programs and provides general affordability planning guidance for use in structuring these programs. The Deputy is also responsible for leading the Defense Resources Board (DRB). [Ref. 23:p. 9]

2. Under Secretary of Defense for Acquisition and Technology (USD(A&T))

The Under Secretary of Defense for Acquisition and Technology is the Department of Defense's Acquisition Executive for Major Defense Acquisition Programs (MDAPs). The USD(A&T) supervises the entire DoD acquisition system, develops acquisition program guidance and ensures compliance with established policy and procedures, establishes policies for the training and development of acquisition personnel, and chairs the Defense Acquisition Board (DAB). [Ref. 22:p. 27] Figure 6 presents the DoD Acquisition Authority Chain as it pertains to MDAPs. An element of acquisition reform was to consolidate this chain and provide for only four levels of authority. [Ref. 22:p. 23]

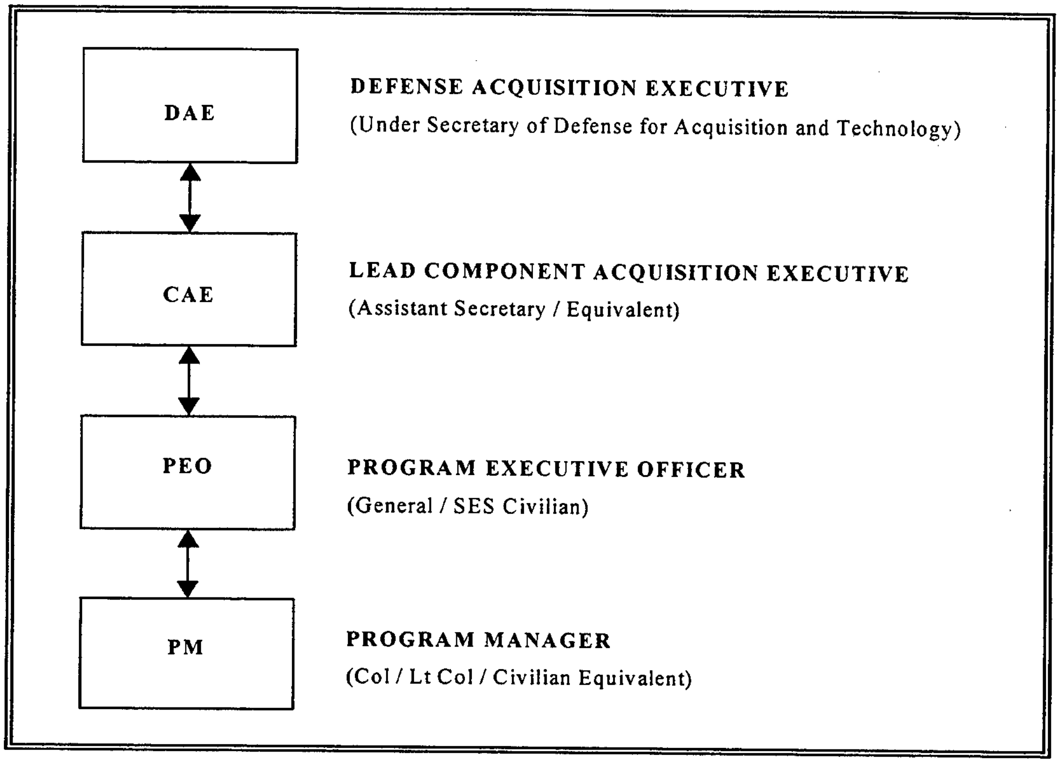

Figure 6. DoD Acquisition Authority Chain. [Ref. 22:p. 24]

3. Secretary of the Navy

The Secretary of each military department is responsible for ensuring that policies and procedures governing the operation of the department's acquisition, requirements, and budgeting systems are effectively implemented. The Secretary will designate a single, full-time Acquisition Executive at the Assistant Secretary level known as the Component Acquisition Executive (CAE). The Secretary will also select Program Executive Officers (PEOs), establish a centralized system for selecting Program Managers (PMs), and charter a Component-level system of acquisition oversight and review. [Ref. 23:p. 9] The Secretary of the Navy oversees these responsibilities for the Marine Corps.

4. The Vice Chairman of the Joint Chiefs of Staff (VCJCS)

The VCJCS chairs the Joint Requirements Oversight Council (JROC), vice-chairs the Defense Acquisition Board, and represents the Commanders-in-Chiefs of the Unified Combatant Commands on acquisition and requirements matters. [Ref. 23:p. 9]

5. Component Acquisition Executives (CAEs)

The CAE supervises the operation of the acquisition system within their respective Component and are responsible for enforcing policies established by the USD(A&T). CAEs also serve as decision authorities for assigned programs. [Ref. 23:p. 10]

6. Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RD&A))

The ASN(RD&A) is the senior official in the Department of the Navy responsible for acquisition matters. Thus, the ASN(RD&A) is the Navy and Marine Corps' CAE. [Ref. 22:p. 25]

7. Program Manager (PM)

PMs manage their assigned programs in a manner consistent with the policies and principles articulated in DoD 5000.1, DoD 5000.2R, and the PM Bill of Rights. PMs provide assessments of their program's status and risk to higher authorities and to the user or user's representative. PMs actively manage their programs within approved resources, program cost, performance, and schedule parameters. They also provide assessments of contractor performance to higher authorities. [Ref. 23:p. 10]

8. Overarching Integrated Product Team (OIPT) Leaders

The OIPT provides strategic guidance to the program office, resolve issues, and provide an independent assessment to the USD(A&T) and the DAB at major decision points, using information gathered through the Integrated Product Team (IPT) process. [Ref. 23:p. 10] "OIPTs for ACAT ID programs are led by the appropriate OSD official. Typically the Director of Strategic and Tactical Systems, the Assistant Deputy Under Secretary of Defense (Space and Acquisition Management), or the Deputy Assistant Secretary of Defense (C3I Acquisition)." [Ref. 22:p. 33]

9. Defense Resources Board (DRB)

The DRB is the senior DoD resource allocation board chaired by the Deputy Secretary of Defense. The DRB advises the Deputy Secretary on major resource allocation decisions, and plays a significant role in the Planning, Programming, and Budgeting System process. [Ref. 22:p. 29]

10. Defense Acquisition Board (DAB)

The DAB is the senior DoD acquisition review board chaired by the USD(A&T). It advises the USD(A&T) on major decisions on individual acquisition programs, acquisition policies, and acquisition procedures. [Ref. 23:p. 10] The USD(A&T) will make a go or no-go decision about the continuation of a system based on cost, schedule, and performance parameters following a DAB review. The USD(A&T)'s decision will be published as an Acquisition Decision Memorandum (ADM). [Ref. 22:p. 35]

11. Joint Requirements Oversight Council (JROC)

The JROC is chaired by the VCJCS. It conducts requirements analyses, validates mission needs and key performance parameters, develops recommended joint priorities for those needs, and advises the Chairman of the Joint Chiefs of Staff (CJCS) on requirements issues. [Ref. 23:p. 11] The JROC will also review MDAPs at each of the Milestones prior to the DAB review. [Ref. 22:p. 30]

12. Integrated Product Teams (IPT)

An IPT is composed of representatives from all appropriate functional disciplines working together to build successful and balanced programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision-making. [Ref. 23:p. 11]

The key individuals and forums in the DoD acquisition system ensure that the right mission need is validated, the right material solution is identified, and the right system is produced for the user. The requirements generation process and the acquisition management process are tools that the key individuals use to accomplish their tasks.

E. REQUIREMENTS GENERATION PROCESS

The requirements generation process is a method used by each service in the DoD to assess the capabilities of their current force structure and its ability to meet the projected threat. The services do this assessment in light of opportunities for technological advancement, cost savings, and changes in the national policy or the doctrine used to support that policy. [Ref. 22:p. 39] This is the environment-doctrine-technology cycle mentioned at the beginning of the chapter. Each service conducts this assessment for the broad category of warfighting responsibility, or mission area, that it has cognizance over. The Marine Corps Combat Development Command (MCCDC) conducts these Mission Area Assessments (MAA) for the Marine Corps. [Ref. 22:p. 39]

As MCCDC conducts a MAA, it may determine that a warfighting deficiency exists, or an opportunity to provide new capabilities exists. These deficiencies or opportunities can have either a material or nonmaterial solution. Nonmaterial solutions such as changing or improving tactics, doctrine, or training are preferred because of lower costs in relation to a material solution. If a deficiency can not be meet by a nonmaterial solution, then the requirement for a material solution is documented in a Mission Need Statement (MNS). The MNS describes the material solution in broad terms and specifies a needed capability, not a specific weapons system. [Ref. 22:p. 40]

Once a MNS for a major defense acquisition program (MDAP) is generated by MCCDC and approved by the Commandant of the Marine Corps, it gets forwarded to the Joint Requirements Oversight Council (JROC) for validation and approval. Validation of the MNS by the JROC confirms that the need to correct the deficiency or exploit the new capability exists and cannot be resolved by a nonmaterial solution. Approval simply means that the JROC concurs that the need is valid and that the validation process is complete. An approved MNS for a MDAP is forwarded by the JROC to the Under Secretary of Defense (Acquisition and Technology) (USD(A&T)). A disapproved MNS is returned to the originator. [Ref. 22:p. 41] If the USD(A&T) concurs with the MNS, then approval to enter Milestone 0 is granted. "A favorable Milestone 0 decision marks the transition from the requirements generation process to the acquisition process." [Ref. 22:p. 42]

F. ACQUISITION MANAGEMENT PROCESS

The acquisition management process is a generic model that all MDAPs follow as they progress throughout their life cycle. The model consists of milestones and phases that allow for review of the program by key individuals so they can monitor and administrate the program's progress, identify problems with the program, and make any necessary corrections to the program. [Ref. 22:pp. 45-46]

DoD 5000.2-R defines a major milestone as, "... the decision point that separates the phases of an acquisition program." [Ref. 5:p. 3] For a MDAP that is designated Acquisition Category I(D) (ACAT I(D)), the USD(A&T) is the individual, or Milestone Decision Authority (MDA), who authorizes the program's entry into the next phase. The DoD 5000.2-R also describes the acquisition phase:

> All the tasks and activities needed to bring the program to the next major milestone occur during an acquisition phase. Phases provide a logical means of progressively translating broadly stated mission needs into well-defined system-specific requirements and ultimately into operationally effective, suitable, and survivable systems. [Ref. 5:p. 2]

Figure 7 depicts the acquisition management process model with its various phases and milestones, each of which will be described briefly.

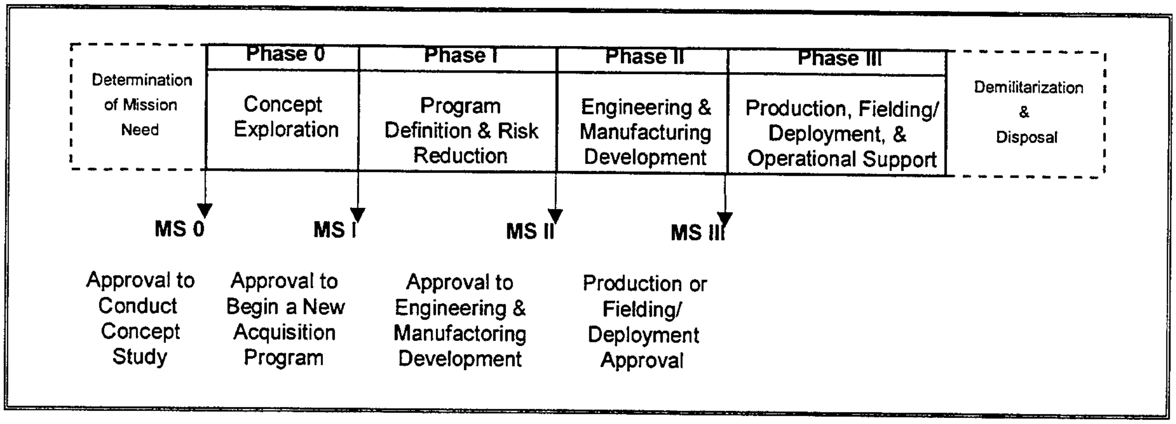

Figure 7. DoD Acquisition Management Process Model [Ref. 22:p. 45]

1. Phase 0: Concept Exploration

The Concept Exploration (CE) phase consists of competitive and parallel short-term concept studies. DoD 5000.2R states:

> The focus of these efforts is to define and evaluate the feasibility of alternative concepts and to provide a basis for assessing the relative merits (i.e. advantages and disadvantages, degree of risk) of these concepts at the next milestone decision point. Analysis of alternatives shall be used as appropriate to facilitate comparisons of alternative concepts. The most promising system concepts shall be defined in terms of initial, broad objectives for cost, schedule, performance, software requirements, opportunities for tradeoffs, overall acquisition strategy, and test and evaluation strategy. [Ref. 5:Part 1.4.2]

2. Phase I: Program Definition and Risk Reduction

The Program Definition and Risk Reduction (PDRR) phase is generally characterized by developing measures to aid in reducing the risk of incorporating new technologies into the system. [Ref. 22:p. 48] DoD 5000.2R further states:

> During this phase, the program shall become defined as one or more concepts, design approaches, and/or parallel technologies are pursued as

> warranted. Assessments of the advantages and disadvantages of alternative concepts shall be refined. Prototyping, demonstrations, and early operational assessments shall be considered and included as necessary to reduce risk so that technology, manufacturing, and support risks are well in hand before the next decision point. Cost drivers, life-cycle cost estimates, cost-performance trades, interoperability, and acquisition strategy alternatives shall be considered to include evolutionary and incremental software development. [Ref. 5:Part 1.4.3]

3. Phase II: Engineering and Manufacturing Development

"The primary objectives of this phase are to: translate the most promising design approach into a stable, interoperable, producible, supportable, and cost-effective design; validate the manufacturing or production process; and, demonstrate system capabilities through testing." [Ref. 5:Part 1.4.4] The testing conducted during Engineering and Manufacturing Development (EMD) is designed to ensure that specifications are met and to ensure the system is operationally effective and suitable. [Ref. 22:p. 49] Additionally, Low Rate Initial Production (LRIP) will occur while the EMD phase is continuing as both the test results and design fixes or upgrades are incorporated into the system. [Ref. 5:Part 1.4.4]

4. Phase III: Production, Fielding/Deployment, and Operational Support

The Production, Fielding/Deployment, and Operational Support (PF/DOS) phase will often overlap with the EMD phase, especially when Low Rate Initial Production (LRIP) is an element of the program's acquisition strategy. [Ref. 22:p.49] DoD 5000.2R states that the objectives of the PF/DOS phase are to, "achieve an operational capability that satisfies mission needs." By satisfying a mission need, the acquisition management process completes the cycle that began in the requirements generation process.

DoD 5000.2R further states that:

> Deficiencies encountered in Developmental Test and Evaluation (DT&E) and Initial Operational Test and Evaluation (IOT&E) shall be resolved and fixes verified in Follow-on Operational Test and Evaluation (FOT&E). During fielding / deployment and throughout operational support, the potential for modifications to the fielded / deployed system continues. [Ref. 5:Part 1.4.5]

Upon completion of a system's useful life, the Program Manager (PM) must ensure it is demilitarized and disposed. The demilitarization and disposal process must be controlled and meet environmental, safety, and security standards. Disposal of the system completes the acquisition cycle. [Ref. 22:p.49] As seen, the three acquisition phases allow for the completion of the tasks and activities needed to bring the program to the next major milestone.

5. Milestone 0: Approval to Conduct Concept Studies

The USD(A&T) will convene a Milestone 0 Defense Acquisition Board (DAB) to review the mission needs statements (MNS) validated by the JROC. The USD(A&T) will also identify possible materiel alternatives to be examined, authorize concept studies, designate the lead organization, and establish exit criteria for Phase 0. [Ref. 22:p. 47] A favorable Milestone 0 decision does not mean that a new acquisition program has been initiated, it simply means that concepts for material solutions to a mission need can be explored. [Ref. 5:Part 1.5.1]

6. Milestone I: Approval to Begin a New Acquisition Program

"The purpose of the Milestone I decision point is to determine if the results of Phase 0 warrant establishing a new acquisition program and to approve entry into Phase I, Program Definition and Risk Reduction." [Ref. 5:Part 1.5.2] At this milestone, the PM shall submit an acquisition strategy, an Acquisition Program Baseline (APB), and proposed Phase I exit criteria to the MDA for approval.

From a test and evaluation perspective, the Director of Operational Test and Evaluation (DOT&E) and the Director of Test, Systems Engineering and Evaluation (DTSE&E) shall approve the PMO's Test and Evaluation Master Plan (TEMP) for all Office of the Secretary of Defense (OSD) test and evaluation oversight programs. Should full-up, system-level Live Fire Test and Evaluation (LFT&E) be deemed unreasonably expensive and impractical, the PM shall request a waiver and submit alternative LFT&E plans for approval by Milestone II. [Ref. 5:Part 1.5.2]

7. Milestone II: Approval to Enter Engineering and Manufacturing Development

"The purpose of the Milestone II decision point is to determine if the results of Phase I warrant continuation of the program and to approve entry into Engineering and Manufacturing Development (applies to both hardware and software)." [Ref. 5:Part 1.5.3] At this milestone, the PM will submit an updated acquisition strategy and APB. The PM will also develop and submit Phase II exit criteria, LRIP quantities, and LRIP exit criteria for approval by the MDA. Additionally, the DOT&E and DTSE&E shall review and approve an updated version of the PM's TEMP for all OSD test and evaluation related oversight programs. [Ref. 5:Part 1.5.3]

8. Milestone III: Production or Fielding/Deployment Approval

This milestone is the decision point that authorizes entrance into the production of a system. The Program Manager will again submit updates of the acquisition strategy and the APB. If appropriate, Phase III exit criteria will be established. Provisions for evaluation of post-deployment performance will also be established by the PM for review by the MDA. [Ref. 5:Part 1.5.4] With respect to test and evaluation, Title 10 USC2399 & USC2366 state that, "the decision to proceed beyond LRIP cannot be finalized until the DOT&E Beyond LRIP and LFT&E reports are received by the Congressional Defense Committees." [Ref. 5:Part 1.5.4]

G. CHAPTER SUMMARY

As described in this chapter, the acquisition management process model, with its milestones and phases, allows for review of the program by key individuals who monitor and administrate the program's progress, identify problems, and make necessary corrections. Combined with the requirements generation process, the user will ultimately receive a system that meet the mission need. The next chapter deals specifically with test and evaluation and its role in the DoD acquisition process.

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IV. DEPARTMENT OF DEFENSE TEST AND EVALUATION OVERVIEW

A. INTRODUCTION

This chapter provides the reader with an understanding of the various types of test and evaluation conducted in the DoD acquisition cycle. This chapter will describe the primary types of test and evaluation, T&E's role in the acquisition process, T&E organizations in the DoD and the USMC, and lessons learned from previous testing of major acquisition programs.

B. TEST AND EVALUATION DEFINED

For acquisition programs, test is defined as:

> Any program or procedure which is designed to obtain, verify, or provide data for the evaluation of: research and development (other than laboratory experiments); progress in accomplishing development objectives; or performance and operational capability of systems, subsystems, components, and equipment items. [Ref. 24:p. B-104]

Evaluation is defined as, "the review, analysis, and assessment of data obtained from testing or other sources." [Ref. 25:Sect. 3.1] When used together as a single concept, test and evaluation can be defined as, "the process by which a system or components are compared against requirements and specifications through testing." [Ref. 24:p. B-104] Thus, test and evaluation (T&E) is, "the deliberate and rational generation of data, which concerns the nature of the emerging system, and the creation of information useful to the technical and managerial personnel controlling its development." [Ref. 26:p. 7]

The purpose of test and evaluation is to identify the areas of risk in a defense system's development and acquisition program so that the risk can then be reduced or eliminated. Decision-makers rely on test and evaluation results to verify the attainment of technical performance parameters by the tested system. Decision-makers also use the results to determine if the developing system is operationally effective, operationally suitable, and survivable in the environment for its intended use. [Ref. 26:p. 5]

C. DEVELOPMENTAL TEST AND EVALUATION

Developmental T&E occurs throughout the life of an acquisition system, and is generally conducted by the contractor and government while being planned and monitored by the Program Management Office. The purpose of Developmental test and evaluation (DT&E) is to, "assist in engineering design and development, to verify that technical performance specifications have been met and to certify the system is ready for IOT&E." [Ref. 27] The key to DT&E is its focus on verification of the system's ability to meet technical performance specifications. Because of the technical focus, DT&E includes the testing and evaluation of components, subsystems, preplanned product improvement changes, and hardware/software integration. [Ref. 27]

In the early phases of a system's development, DT&E will rely on the use of models, simulations and test-beds. As the system matures, DT&E will occur using prototypes or full-scale engineering development models of the system as well as production articles for production qualification testing and production acceptance testing. Thus, DT&E supports the system design process through a Simulation Test and Evaluation Process (STEP) approach as mandated by the Director, Test, Systems Engineering, and Evaluation (DTSE&E). [Ref. 27]

Developmental test and evaluation requires a close working relationship between the contractor and government personnel. Because the program manager remains ultimately responsible for the success or failure of the program,

> The PM and the staff test specialists must foster an environment that provides the contractor with sufficient latitude to pursue innovative solutions to technical problems and, at the same time, provides the data needed to make rational trade-off decisions between cost, schedule and performance as the program progresses. [Ref. 27]

The contractor's role in the total test program is significant. Therefore, it is important that the contractor establishes an integrated test plan early to ensure that the scope of the contractor's test program satisfies government and contractor test objectives. [Ref. 27]

D. OPERATIONAL TEST AND EVALUATION

Operational test and evaluation (OT&E) serves the primary purpose of determining whether systems are operationally effective and suitable for the intended use by representative users before full scale production or deployment. [Ref. 26:p. 65] OT&E is also conducted to identify needed modifications to the system, and to provide information on tactics, doctrine, organization, and personnel requirements. [Ref. 28]

The key to OT&E is its focus on operational effectiveness and suitability. The Defense Systems Management College defines them as follows:

> **Operational Effectiveness**: The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, tactics, survivability, vulnerability, and threat. [Ref. 26:p. 57]

> **Operational Suitability**: The measure of the ability of the intended users to use the system with its intended support system and resources. The degree to which a system can be placed satisfactorily in field use with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime use rates, maintainability, safety, human factors, manpower supportability, logistics supportability, natural environment effects and impacts, documentation and training requirements. [Ref. 26:p.58]

Operational test and evaluation can be divided into three general phases: Operational Assessments (OA), Initial Operational Test and Evaluation (IOT&E) and Follow-on Operational Test and Evaluation (FOT&E). Title 10, USC Section 2399 mandates that IOT&E be conducted before proceeding beyond low rate initial production (normally Milestone III) to ensure that a system has valid operational effectiveness and suitability. The law also requires that typical users conduct IOT&E on a system as close to a production configuration as possible, in an operationally realistic environment. Follow-on test and evaluation is then conducted on already deployed systems to determine if operational effectiveness and suitability are actually being attained. [Ref. 28]

E. EARLY OPERATIONAL ASSESSMENT

An Early Operational Assessment (EOA) is a category of Operational Assessments (OA) that is conducted by a service's Operational Test Activity (OTA) during the early stages of Phase 0 (CE) or advanced development of the system design during Phase I (PDRR). An EOA will generally evaluate an emerging system's design features by reviewing developmental testing of brassboard systems, mock-ups, or actual prototypes as test articles. [Ref. 29] An EOA may make heavy use of modeling and simulation as an evaluation tool. Although all Critical Operational Issues (COIs) may be addressed during an EOA, COIs are usually not fully resolved until later in the program when actual production representative systems are available for the more comprehensive Initial Operational Test and Evaluation (IOT&E). [Ref. 29]

The key element of an EOA is its ability for operational testers and user representatives to identify design concerns early enough in the program to be cost effective to correct. These early corrections could significantly enhance design and reduce total ownership costs of the system. Tom Carter of the Office of the Director, Operational Test and Evaluation (DOT&E) asserts:

> Early involvement of the Operational testers produces large payoffs for the minimal resources usually required. From assisting the user in stating operational requirements in a manner appropriate for the developer and the operational tester, to providing an independent assessment of the emerging system capabilities in a realistic environment early enough to affect system design with minimal disruption, the products gained from an EOA usually are well worth the cost in dollars and time. [Ref. 29]

Carter further states that, "A Project Manager's (PM's) failure to get the OTA involved early and substantially will likely have adverse effect later in the program, when the political cost could be great." [Ref. 29]

F. LIVE FIRE TEST AND EVALUATION

Live Fire Test and Evaluation (LFT&E) is a significant element of a major defense acquisition system's pre-production readiness decision. Congress has mandated (10 USC Section 2366) that LFT&E be conducted on a covered system, major munitions program, missile program, or product improvement to a covered system, major munitions program, or missile program before it can proceed beyond low-rate initial production. [Ref. 5:Part 3.4.9] Congress has also mandated that a program may not proceed beyond low-rate initial production until realistic survivability or lethality testing is completed, and that the LFT&E report required by Title 10, USC Section 2366 is submitted to the appropriate congressional committees. [Ref. 5:Part 3.4.9]

The purpose of LFT&E is to assess a system's vulnerability/survivability and its lethality. Survivability is defined as, "the capability of a system and crew to avoid or withstand a man-made hostile environment without suffering an abortive impairment of its ability to accomplish it designated mission." [Ref. 5:App. IV] Though often used interchangeably, vulnerability is actually a subset of survivability, and specifically refers to a system's characteristics that cause it to suffer degradation as a result of being subject to the hostile environment. Lethality is defined as, "the ability of a munition to cause damage that will cause the loss or a degradation in the ability of a target system to complete its designated mission(s)." [Ref. 5:App. IV] DoD 5000.2R further identifies the four primary objectives of LFT&E [Ref. 5:App. IV]:

- To provide information to decision-makers on potential user casualties, vulnerabilities, and lethality, taking into equal consideration susceptibility to attack and combat performance of the system.
- To ensure that knowledge of user casualties and system vulnerabilities or lethality is based on testing of the system under realistic combat conditions.
- To allow any design deficiency identified by the testing and evaluation to be corrected in design before proceeding beyond low-rate initial production.
- To assess battle damage repair capabilities and issues.

Survivability testing often begins at the component, subsystem, and subassembly level as the system progresses through Phase 0 and Phase I. Survivability testing culminates in Phase II with tests of the complete covered system entirely configured for combat. [Ref. 5:Part 3.4.9] Survivability testing is complex, and requires specialized test facilities that can measure the effects of enemy weapons systems and munitions. Because to the nature of the threat environment, testing and test results are often classified.

G. MULTI-SERVICE TEST AND EVALUATION

Multi-service test and evaluation is conducted when, "a system is determined to be of use to more than one service and acquisition of that system will be conducted by those services, or when a system will be required to interface with equipment of another service." [Ref. 30:p. 22-1] One of the services involved in the acquisition of the system will be designated the Lead Service. The Lead Service is then responsible for the conduct of test planning, execution, and reporting. The Lead Service must coordinate to ensure that the participating services' unique critical issues and requirements are being met with the test management plan. Because of the potential differing mission use of the system, test results must be evaluated in light of each services' requirements. [Ref. 30:p. 6-7]

H. CONCURRENT AND COMBINED TEST AND EVALUATION

Concurrent and combine test and evaluation are often confused with each other or are used synonymously. Concurrent test and evaluation refers to cases where two different types of testing (i.e. DT&E and OT&E) take place at the same time. The two tests, however, are separate and distinct activities. Combined test and evaluation is a single test program or event that supports the objectives of the two different tests. [Ref. 30:p. 9-1] Table 2 outlines stated advantages and limitations of both concurrent and combined testing.

Combined Testing and Evaluation	
Advantages	**Limitations**
-Shortens time required for testing and, thus, the acquisition cycle. -Achieves cost savings by eliminating redundant activities. -Early involvement of OT&E personnel during system development increases their familiarity with system. -Early involvement of OT&E personnel permits communication of operational concerns to developer in time to allow changes in system design.	-Requires extensive early coordination. -Test objectives may be compromised. -Requires development of DT/OT common test data base. -Combined testing programs are often conducted in a development environment. -Test will be difficult to design to meet DT and OT requirements. -The system contractor is prohibited by law from participating in IOT&E. -Time constraints may result in less coverage than planned for OT&E objectives.
Concurrent Testing and Evaluation	
Advantages	**Limitations**
-Shortens time required for testing and, thus, the acquisition cycle. -Achieves cost savings by overlapping redundant activities. -Provides earlier feedback to the development process.	-Requires extensive coordination of test assets. -If system design is unstable and far-reaching modifications are made, then OT&E must be repeated. -Concurrent testing programs often do not have developmental test data available for OT&E planning and evaluation. -Contractor personnel frequently perform maintenance functions in a DT&E. Logistics support by user must be available earlier for IOT&E. -Limited test assets may result in less coverage than planned for OT&E objectives.

Table 2. Advantages and Limitations: Combined and Concurrent Testing [Ref. 30:p.9-4]

I. JOINT TEST AND EVALUATION

Joint test and evaluation differs from multi-service test and evaluation in that joint T&E is a specific program activity sponsored and funded by the OSD. Joint T&E programs are a means to examine joint service doctrine and tactics, and are not meant for acquisition purposes. [Ref. 30:p.6-7]

J. TESTING IN THE ACQUISITION PROCESS

The test and evaluation process is an important element of decision-making in the DoD acquisition process. Decision-making authorities use test and evaluation results to support trade-off analysis, identify risk drivers, and assess the maturity of system development. Program Managers develop a test and evaluation strategy to ensure that the system they oversee meets the criteria to advance to the next phase, and ultimately to ensure that the system meets the user's needs. [Ref. 30:p. 1-1] Test and evaluation events occurring in the different phases will be described as they relate to a system's preparation for milestone review. Figure 8 provides a graphic overview of the different test and evaluation events as they occur throughout the DoD's acquisition process.

1. Concept Exploration - Phase 0

Formal test and evaluation planning begins in this phase. The Test and Evaluation Integrated Product Team (T&E IPT) will form and begin working as a group to develop and resolve test related issues. [Ref. 31:Chap. 4-4] Appropriate test and evaluation shall be accomplished and documented to assist key acquisition personnel in selecting the preferred alternative system concepts, and associated technologies and designs for the proposed systems. The use of laboratory testing, modeling, and simulation by the contractor and the government is encouraged in this phase to aid in assessing the technological feasibility of alternatives. [Ref. 31:Chap. 4-4]

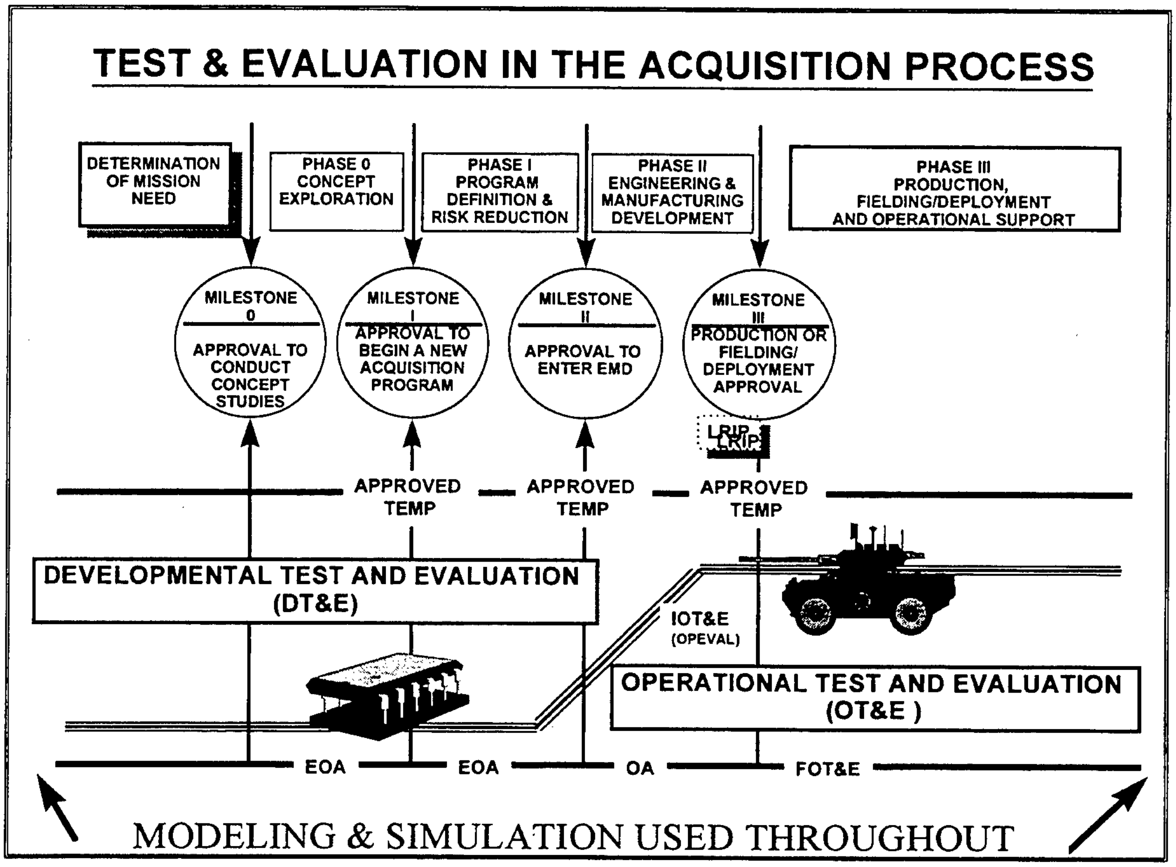

Figure 8. Test and Evaluation in the Acquisition Process [Ref. 28]

If a preferred system concept is identified, early test and evaluation will provide data for the concept's evaluation with respect to potential requirements, tactics, doctrine, organization, training, transportability, and logistic support. [Ref. 31:Chap. 4-4] Testing in the CE phase is generally limited in order to devote no more resources than necessary to the process of selecting a concept and to evaluate the ability of alternative systems to satisfy the MNS. [Ref. 25:Sect. 6.2] The level of testing in the CE phase is also dependent upon the test article's state of design. Efforts in this phase may include modeling and simulations, testing of "breadboards" and "brassboards", testing of components and subsystems, and proving concepts. Test and evaluation at this point helps to, "identify and assess high-risk areas, critical components and subsystems; establish safety for operational testing; and assess the operational impact of the preferred concept." [Ref. 31:Chap. 4-4]

The data and information obtained from CE phase testing can be used to support a go ahead decision at the Milestone I review. [Ref. 30:p. 7-1] In preparation for the review, the Program Manager, or his designated Test and Evaluation Officer, will be concerned with the following questions [Ref. 28]:

- What T&E data exists? Does analysis conclude that the concept(s) will work?
- Can requirements, as stated be evaluated?
- Does the existing T&E infrastructure/technology base permit evaluation? Approximately what is the cost and time frame to create the infrastructure/technology base required?
- How can T&E favorably impact risk management or risk reduction?
- What alternatives exist to testing/test assets? What are the risks?
- Has the preliminary Test and Evaluation Master Plan been approved? Are the Critical Operational Issues, minimum acceptable operational performance requirements, and the Critical Technical Parameters included?
- What are the recommended Phase I "exit criteria"?

The PM and T&E Officer will have ensured that the following key documentation is consistent at the time of the Milestone I review: the Acquisition Decision Memorandum (ADM) (exit criteria), the Operational Requirement Document (ORD), the Mission Need Statement (MNS), the System Threat Assessment, and the Test and Evaluation Master Plan (TEMP). [Ref. 28]

2. Program Definition and Risk Reduction - Phase I

Test and evaluation planning in the Program Definition and Risk Reduction Phase is based on the prototypes emerging from the selected concepts. Developmental T&E in the PDRR phase is conducted to, "assist with engineering design, system development, risk identification and to evaluate the contractor's ability to attain desired technical performance in system specifications and achieve program objectives." [Ref. 30:p. 1-5] DT&E will include contractor/government integrated testing, engineering design testing, and advanced development testing which usually occurs at contractor facilities. [Ref. 30:p. 7-3]

Modeling and simulations will increase in significance during PDRR as it will be used to assess areas of safety, reliability, and other areas where test limitations prevent direct testing or observation. Modeling and simulations will also be used as a means to keep test costs to a minimum. [Ref. 30:p. 7-3]

Operational T&E in the PDRR phase generally consists of Early Operational Assessments conducted by a service's operational test and evaluation activity. These EOAs focus on the prototypes' potential to meet existing critical operational issues by representative users in realistic combat environments. Combined DT and OT is encouraged during PDRR as another means to reduce test costs and schedules.

The information gathered from both developmental and operational test and evaluation in the PDRR phase contributes significantly to the Milestone II decision. The Milestone II decision will establish more specific cost, schedule, operational effectiveness and suitability objectives and thresholds. Documents of interest to the T&E Officer at the time of the Milestone II review include the ADM (exit criteria), updated TEMP, updated ORD, Acquisition Program Baseline (APB), the early Operational Assessment and low-rate initial production (LRIP) guidance. [Ref. 28] As with Phase 0, the T&E Officer and the T&E IPT will need to address the following questions in preparation for the Milestone II review [Ref. 28]:

- Will the Prototype(s) work?
- Can requirements, as stated, be evaluated?
- Does the existing T&E infrastructure/technology base permit evaluation? Approximately what is the cost and time frame to create the infrastructure/technology base required?
- What are the capabilities/limitations of each Prototype versus enemy threats?
- How can T&E favorably impact risk management or risk reduction? What alternatives exist to testing/test assets? What are the risks?
- Has the TEMP been approved? Does the TEMP contain the performance parameters reflected in the ORD, Alternative Analysis, and APB? Are they consistent?
- Is each proposed Prototype feasible? Is one preferred?

- What are the recommended Phase II T&E "exit criteria"?

- What are the recommended criteria for certification of readiness for final IOT&E?

- Does the Early Operational Assessment (EOA) address the availability of and planning for resources projected for OT&E test events?

Following Milestone II approval, program testing enters the Engineering and Manufacturing Development Phase.

3. Engineering and Manufacturing Development - Phase II

The Defense Systems Management College (DSMC) indicates that during the EMD Phase, "the selected system and its principal items of support are fabricated as engineering development models." [Ref. 28] The system will also be integrated, tested, evaluated, and documented to assure that the system's design is stable. The system will then be assessed against the contract specifications and technical parameters, evaluated as to its operational effectiveness and suitability in realistic combat environments, matched against user requirements, and rated for its ability to enter into production. [Ref. 31:Chap. 4-8]

Developmental testing in EMD, "determines whether engineering is complete (including design and maintenance engineering), identifies design problems, recommends redesign, ascertains that solutions are in hand, supports decision makers and provides recommendations as to readiness of the system to enter OT." [Ref. 31:Chap. 4-8] The goal of developmental test and evaluation in EMD is to reduce design risk, support the evaluation of critical technical parameters, and to ensure contractual compliance by the contractor. DT&E will also validate the general and detailed specifications and drawings that will be used in the final production of the system. [Ref. 31:Chap. 4-8]

Operational testing and evaluation in the EMD phase is very significant. The EOA and the Initial Operational Test and Evaluation (IOT&E) are conducted on production representative systems, or on Low Rate Initial Production (LRIP) systems. EOAs and IOT&E are conducted by user organizations in field exercises that closely represent combat-like conditions. These fleet units will assess not only the weapon system, but will also assess the doctrine, tactics, logistical support, and organizational structure necessary to support the system in an operational environment. [Ref. 30:p. 12-5] The goal of operational testing in EMD is to ensure the system meets user requirements and minimum operational thresholds, and is ready to enter full-rate production. [Ref. 30:p. 12-5]

Department of the Army (DA) Pamphlet 73-1 describes EMD as the most test-intensive phase of the acquisition process. It further states that T&E IPTs should be held often to ensure that test details are integrated allowing problems to be anticipated and resolved in a timely manner. [Ref. 31:Chap. 4-8] The PM's T&E Officer and the T&E IPT will need to address the following questions during EMD in preparation for the Milestone III review [Ref. 28]:

- For DT&E, what are the capabilities and limitations of each Production Prototype being developed? What is the confidence level in this data/assessment?

- For OT&E, are the Production Prototypes suitable and effective in satisfying the mission need? What is the confidence level of this assessment?

- Have key performance objectives/thresholds been validated versus advanced threats?

- Have requirement changes been incorporated into the APB, ORD, and contract specifications?

- Have specification changes been reflected back to requirements and incorporated into the APB and ORD?

- Does the TEMP reflect the changes in into the APB, ORD, and contract specifications? Has it been approved?

- Should there be a major modification decision, what are the recommended Phase III T&E 'exit criteria'?

Coordination among all agencies involved in the T&E IPT is critical because test results must be reviewed by higher authorities prior to the Milestone III review. Specifically:

> The director of OT&E is required by law to document his assessment of the adequacy of OT&E and Live Fire T&E, and the reported operational effectiveness and suitability and vulnerability/lethality of the system. This is done in the Beyond LRIP Report, which must be delivered to Congress prior to proceeding beyond LRIP. [Ref. 28]

The EMD phase will end with the Milestone III review for a decision to enter full-rate production of the system. Testing will continue into the next phase.

4. Production, Fielding/Deployment, Operations, and Sustainment – Phase III

The objectives of the production, fielding/deployment, operations, and sustainment phase are to complete the production processes once design stability has been achieved, and to produce items for the operational forces. [Ref. 28] The goals for full-rate production are, "to achieve and maintain efficient and stable production; achieve an operational capability that satisfies mission needs; and conduct an operational testing program that verifies performance and quality, and corrects deficiencies." [Ref. 28] Testing supports these goals and objectives by evaluating the system in Production Verification Testing (PVT), Production Acceptance Test and Evaluation (PAT&E), and Follow-on Test and Evaluation (FOT&E). At a minimum, T&E will address the following questions [Ref. 28]:

- For DT&E, what are the deployed system's demonstrated capabilities and limitations? What are the capabilities and limitations of modifications and upgrades?

- For OT&E, does the system continue to be operationally suitable and effective in operational use? Do proposed modifications and upgrades increase the suitability and effectiveness of the system?

- Have performance objectives/thresholds versus advanced threats been validated? Does the system meet these performance objectives/thresholds?

- Is the TEMP current?

The ultimate result of test and evaluation in the PF/DOS phase is the determination if the fielded system is meeting the user's needs and if any shortcomings and deficiencies need to be corrected to improve performance. [Ref. 28]

K. TEST AND EVALUATION ORGANIZATIONS

Two primary offices oversee the test and evaluation process in the OSD: the Director, Strategic and Tactical Systems (DS&TS) and the Director Operational Test and

Evaluation (DOT&E). Representatives from both DOT&E and DS&TS organizations actively participate in program's integrated product teams (IPT). [Refs. 28, 105] DoD test community restructuring by the Under Secretary of Defense for Acquisition and Technology resulted in the former Director, Test, Systems Engineering, and Evaluation (DTSE&E) being consolidated into DS&TS structure. DS&TS now has a subordinate Developmental Testing division. That DT division carries out the same responsibilities as the previous DTSE&E office. [Ref. 105] This change occurred during the conduct of the research, and where appropriate, references are still made to DTSE&E.

1. Developmental Test and Evaluation Organizations

The Director, Strategic and Tactical Systems (DS&TS) serves as the principal staff assistant and advisor to the USD(A&T) for developmental test and evaluation matters, and has authority and responsibility for all DT&E conducted on designated major programs and OSD Oversight programs. [Ref. 28] Some of the DS&TS's primary duties and responsibilities include [Ref. 28]:

- Serving as the focal point for coordination of all major and OSD oversight program test and evaluation master plans (TEMPs). Signs for approval of DT&E portion of TEMPs.

- Reviewing major defense acquisition program documentation for DT&E implications and resource requirements to provide comments to the USD(A&T), DAB, OIPT, or MDA.

- Observing DT&E to ensure adequacy of testing and to assess test results.

- Providing the DAE and OIPT with a technical assessment of development T&E conducted on a weapon system.

- Providing advice and makes recommendations to the USD(A&T) and issues guidance to the component acquisition executives with respect to DT&E.

The Marine Corps Systems Command (MARCORSYSCOM) is responsible for the oversight of developmental test and evaluation of Marine Corps systems. The Test and Evaluation Section (PSE-T), Systems Engineering Branch (PSE), Program Support Directorate, of MARCORSYSCOM provides the Program Manager with assistance in all T&E related matters. Specific guidance can be provided to the PM in developing test plans and the Test and Evaluation Master Plan. [Ref. 25:Sect. 2.3] The Marine Corps Program Managers Test and Evaluation Handbook states that, "The recurrent and prominent lessons learned in past T&E programs point to the continuing need for coordination between PST-E and the PM in the supervision, planning, conduct and analysis of major DT&E events." [Ref. 25:Sect. 5.2]

The Marine Corps is unique in that it has a specialized Amphibious Vehicle Test Branch (AVTB) located in Camp Pendleton, California. AVTB is currently a subordinate element of the Program Management Office of the Assault Amphibian Vehicle (PM AAV) who in turn reports to MARCORSYSCOM. AVTB provides for the developmental testing of amphibious vehicles, and focuses on waterborne critical technical parameters such as water speed and endurance, seaworthiness, surf zone transitions, and waterborne reliability. [Ref. 33]

2. Operational Test and Evaluation Organizations

The Director, Operational Test and Evaluation (DOT&E) establishes department policies and procedures for operational test and evaluation and live-fire test and evaluation. [Ref. 23:p. 10] As seen in Figure 9, the director reports directly to the SECDEF and has special reporting requirements to the Congress. Some of the specific duties of DOT&E include [Ref. 28]:

- Obtaining reports, information, advice and assistance as necessary to carry out assigned functions (DOT&E has access to all records and data in DoD on acquisition programs).

- Signing the TEMPs for approval of OT&E and LFT&E and approving the OT&E funding for major systems acquisition.

- Approving test plans on all major systems prior to system starting OT&E and LFT&E (approval in writing required before operational testing may begin).

- Providing observers during preparation and conduct of OT&E and LFT&E.

- Analyzing results of OT&E and LFT&E conducted for each major or designated defense acquisition program and submitting a report to the SECDEF and the Congress on the adequacy of the test and evaluation performed.

- A final decision to proceed with a major program beyond LRIP cannot be made until DOT&E has reported (Beyond LRIP and LFT&E Report(s)) to the SECDEF and to congressional Committees on Armed Services and Appropriations.

A 1997 General Accounting Office (GAO) report assessed the impact of DoD's Office of the Director of Operational Test and Evaluation. The report states that DOT&E oversight of operational testing and evaluation increased the probability that testing would be more realistic and more thorough, and that DOT&E can reduce the risk that systems are not adequately tested prior to the full-rate production decision. [Ref. 35:p. 3] The report further states that:

> Specifically, DOT&E was influential in advocating increasing the reliability of the observed performance and reducing the risk of unknowns through more thorough testing; conducting more realistic testing; enhancing data collection and analysis; reporting independent findings; and recommending follow-on operational test and evaluation when suitability or effectiveness was not fully demonstrated prior to initiating full-rate production. [Ref. 35:p. 3]

The GAO report concludes that the effectiveness of DOT&E lies with its independence and its authority to report directly to Congress on test and evaluation matters. [Ref. 35:p. 3]

The Marine Corps Operational Test and Evaluation Activity (MCOTEA) was established on 1 April 1978 to serve as the Marine Corps' independent operational test activity. [Ref. 34] MCOTEA's primary functions is to ensure that operational testing for Acquisition Category (ACAT) I, II, III, and IV(T) programs are effectively planned, conducted, evaluated, and reported on. [Ref. 25:Sect. 2.3] MCOTEA is also responsible for preparing the Test Planning Document (TPD) and the Detailed Test Plan (DTP) for operational test and evaluation, evaluating and analyzing test results, and preparing the Independent Evaluation Report (IER) for submission to the Commandant of the Marine Corps. [Ref. 25:Sect. 2.3] Other responsibilities include [Ref. 34]:

- Developing OT&E policy.
- Chairing and hosting the Failure Definition/Scoring Criteria (FD/SC) IPT.

- Reviewing the System's Operational Requirements Document (ORD).
- Preparing Part IV of the Test and Evaluation Master Plan.
- Maintaining liaison with Director, Operational Test and Evaluation (DOT&E), the FMF [Fleet Marine Force], and other military activities and commands as required for OT&E matters.

L. CONTRACTOR TEST AND EVALUATION

In addition to government test and evaluation, the contractor plays a significant role in the testing of a new system. The winning contractor is normally required by the Request For Proposal (RFP) to submit an Integrated Engineering Design Test Plan shortly after the contracts initiation for review by the PM and governmental test agencies. [Ref. 30:p. 7-6] The contractor's test plan will include details on testing against the specifications, the Statement of Work (SOW), and testing of the contractor's engineering development and integration process. [Ref. 30:p. 7-6] DSMC's Test and Evaluation Management Guide states, "If the contractor has misinterpreted the RFP requirements and the Integrated Engineering Design Test Plan does not satisfy government test objectives, the iterative process of amending the contractor's test program begins." [Ref. 30:p. 7-6] The process used to reconcile with the contractor over the details of the proposed test plan must be done so as not to have significant effects on contract cost, schedule, or scope, and must ensure that the contractor can meet government test objectives. [Ref. 30:p. 7-6]

The PM is responsible for ensuring that government oversight of contractor testing occurs, and that the government has access to contractor test data, analysis, and results. Government involvement in contractor testing ensures that contractor tests are reliable, and are useful in meeting government test objectives. [Ref. 30:p. 7-5]

M. TEST AND EVALUATION DOCUMENTATION

This section provides the reader with an understanding of the five key test and evaluation related documents: the Test and Evaluation Master Plan (TEMP), the Test Planning Document, the Detailed Test Plan, the Beyond LRIP Report, and the Live Fire Test and Evaluation Report.

1. Test and Evaluation Master Plan

DoD 5000.2R directs the Program Manager to develop a test and evaluation strategy that supports the program's overall acquisition strategy. The Test and Evaluation Master Plan (TEMP) is the required document that identifies the overall structure and objectives of the test and evaluation strategy, and describes the PM's program to implement that strategy. [Ref. 5:App. III] The TEMP provides a framework within which to generate detailed test and evaluation plans, documents schedule and resource implications of the T&E program, and identifies the necessary developmental test and evaluation, operational test and evaluation, and live fire test and evaluation activities. [Ref. 5:App. III]

One of the most critical aspects of the TEMP is how it relates program schedule, test management strategy and structure, and required resources to: Critical Operational Issues (COIs); Critical Technical Parameters; Objectives and Thresholds derived from the Operational Requirements Document (ORD); Evaluation criteria; and Milestone decision points (Exit Criteria). [Ref. 5:App. III] Because of the TEMP's significance, complexity and level of detail, it should be developed through the IPT process. This allows MARCORSYSCOM, MCOTEA, MCCDC, DOT&E, DS&TS, and others early input to the test and evaluation development process.

The DOT&E and DS&TS will be the Office of the Secretary of Defense TEMP approval authorities for an acquisition category (ACAT) I program. The TEMP for an ACAT I program shall be submitted to OSD for approval 30 days prior to the program's Milestone I review. TEMP updates are then required at each milestone review, when the program baseline has been breached, or when the program has changed significantly. [Ref. 5:App. III]

2. Test Planning Document

The Marine Corps PM's T&E Handbook states that, "The purpose of the TPD is to alert the FMF [Fleet Marine Force] that, sometime in the future, FMF resources will be required to support T&E activities." [Ref. 25:App. B] MCOTEA is responsible for developing the TPD as early as possible with input from the Program Manager so that the best estimate of personnel, equipment, and resources can be provided to the FMF. The TPD is required for all OT and combined DT/OT events. The PM's T&E Handbook emphasizes that, "The TPD should be developed early enough to permit allocation of FMF resources and funding into the POM [Program Objective Memorandum] cycle." [Ref. 25:App. B]

3. Detailed Test Plan

The purpose of a Detailed Test Plan (DTP) is to establish specific instructions and guidelines for the conduct of every phase of a test with specific emphasis on data collection and test control. [Ref. 25:App. B] DTPs for operational testing will be developed by MCOTEA, while MARCORSYSCOM and the PM will produce DTPs for government-run developmental testing. Contractor produced DTPs will conform to the provisions of the contract. The PMs T&E Handbook states, "The size and complexity of the DTP will be a function of the system being tested, the amount and adequacy of previous testing, and the type of tests being conducted." [Ref. 25:App. B] In some cases, the DTP can span several volumes.

4. Beyond-Low-Rate Initial Production (LRIP) Report

Before the Milestone Decision Authority (MDA) can finalize the decision to proceed beyond low-rate initial production of a major defense acquisition program, Title 10, USC Section 2399 requires that DOT&E submit a report to the Secretary of Defense, and to the four Defense Committees of the Senate and the House of Representatives. This "Beyond-LRIP" report is prepared by DOT&E's Action Officer responsible for oversight of the major program, and is based mainly on the results of IOT&E. [Ref. 29] The Beyond-LRIP report outlines the Director's official opinion regarding adequacy of the OT&E conducted on the system, and the operational effectiveness and operational suitability of the system as tested. The Beyond-LRIP Report will also normally contain the LFT&E Report required by Title 10, USC Section 2366. [Ref. 29]

When the Beyond-LRIP Report nears completion, DOT&E will normally offer the draft report to the Service for comment. This provides the program manager and service authorities insight into what will be said about the program and its system. It also allows them an opportunity to attach comments to the Beyond-LRIP report before it is sent to the Congress. [Ref. 29]

5. Life Fire Test and Evaluation Report

DoD 5000.2R states that the results and overall evaluation of testing as identified in the program's Live Fire Test and Evaluation strategy will be documented and submitted to DOT&E no later than 120 days after test completion. An independent OSD Live Fire Test and Evaluation Report will then be prepared by the DOT&E within 45 days after receipt of the service's Live Fire Test Report. [Ref. 5:App. IV] Again, Title 10, USC Section 2366 requires that the Secretary of Defense, or the DOT&E as delegated, approve the OSD Live Fire Test and Evaluation Report and submit it to Congress prior to the decision to proceed beyond low-rate initial production. The report shall address the system's capabilities based on survivability and lethality testing. [Ref. 5:App. IV]

N. PREVIOUS TEST AND EVALUATION LESSONS LEARNED

This section presents issues and lessons learned from previous developmental and operational testing of major acquisition programs in the DoD.

1. Developmental Testing Lessons Learned

Captain Arthur J. Aragon, Jr. (USA) analyzed key problems in Developmental Testing and Evaluation (DT&E) in the United States Army by examining seven major defense acquisition programs. His results were published as a Master of Science thesis in 1994 titled A Comparative Analysis of Developmental Test and Evaluation in the United States Army. [Ref. 36] Captain Aragon discovered five common categories of problems associated with the developmental testing of the seven systems. The problems and associated recommendations for improvement are summarized below.

a. Schedule

Captain Aragon concludes that schedule problems were the most common and most significant problem with conducting DT&E. He states, "Schedule problems are caused by the acquisition process which encourages over optimism, unrealistic schedule estimates and emphasizes completing the test on schedule over conducting the test according to plan." [Ref. 36:p. 74] The following recommendations were given to improve schedule issues [Ref. 36:p. 78]:

- Starting with the PM and his staff, more realistic schedule estimates should be made by all agencies involved.
- PMs should hold participative and conclusive TIWGs [Test Integration Working Groups] to address test plans and schedules.
- Historical information and data from previous tests should be used to better estimate future test schedules.

b. Acquisition Process

Captain Aragon asserts that the acquisition process presents a significant problem to conducting DT&E because of the funding process and PM over-optimism. "The funding process rewards PMs for being on schedule, under budget and meeting the criteria of the next milestone, but not for being critical and objective about their system and not for taking a user perspective." [Ref. 36:p. 75] He further concludes that PMs are generally over-optimistic about planning and scheduling issues. Thus, other agencies are forced to sign up to unrealistic plans that are based on meeting an aggressive schedule not based on the system's readiness for testing. [Ref. 36:p. 75] His recommendations for improvement were [Ref. 36:p. 78]:

- The analysts should not promote excessive testing and should integrate other and more efficient methods of evaluation including modeling and simulation.

- Senior decision-makers should reward PMs who are realistic and objective about the development of their system.

c. Test Culture

With respect to environment, Captain Aragon concludes, "that a negative test culture exists and this culture was the basis of many DT&E problems." [Ref. 36:p. 75] This negative image appears to exist because some testers and analysts have earned a poor reputation among PMOs by conducting tests that appeared to add no value to the process. [Ref. 36:p. 75] Captain Aragon made the following recommendations to improve test culture [Ref. 36:pp. 78-79]:

- PMs and contractors should realize the value that DT&E provides to their development effort.

- Testers should educate PMs on their capabilities and demonstrate more flexibility in packaging test programs.

- The PM must make the testers and analysts part of the team and not the bad news messengers.

- Testers and analysts should become more familiar with the system under test to better understand, "What to test?"

d. Resource Management

Captain Aragon determined that improper management of funding and hardware and software resources lead to major problems in DT&E. Specifically, "Lack of funding could delay test setup, delay instrumentation/equipment checks, and reduce needed test support personnel." [Ref. 36:p. 76] He also concludes that developing systems are constrained by limited prototypes, test models, and versions of software. His recommendations for improving resource management included [Ref. 36:p.79]:

- PMs should plan for contingencies and not assume perfect success in the test process.
- PMs should fund testing to insure test resources are available when needed for proper test conduct.
- Tester should become more familiar with the systems under test especially software intensive systems.

e. Changes in Requirements

Changing requirements cause difficulties in defining test requirements, and make test plans and conduct more difficult and expensive than originally estimated. [Ref. 36:p. 76] Changing requirements were determined to result from a lack of coordination and/or communication between agencies and a lack of understanding of DT&E processes among the Combat Developers. This lack of communication results in, "documents such as the ORD, the TEMP, and the contract not matching in terms of requirements." [Ref. 36:p. 76] Captain Aragon's recommendations for improvement were [Ref. 36:p. 79]:

- The PM should insist that a solid, stable, and realistic ORD be maintained.

- The PM should establish a better working relationship among the agencies in defining test requirements.

- The Combat Developer should appreciate the impact that changing requirements has on the system and the test process.

- The PM should ensure that the major documents, to include the contract, are closely coordinated.

As will be seen, problems existing in the developmental testing process also occur in the operational testing process.

2. Operational Testing Lessons Learned

Captain James B. Mills (USA) analyzed Army weapon system Operational Test and Evaluations conducted at Fort Hunter-Liggett, California for his Master of Science thesis, An Analysis of Weapon System Readiness for Operational Testing, published in 1994. [Ref. 37] Captain Mills analyzed the ADATS (LOS-F-H) air defense system, the Avenger (Pedestal Mounted Stinger) air defense system, the OH-58D (AHIP) scout helicopter, and the Apache (AH-64) attack helicopter. Based on his analysis, Captain Mills determined that reoccurring problems in the areas of test schedules, manuals, reports, resources, and training could have a significant impact on a system's ability to successful complete OT&E. [Ref. 37] Negative OT&E results, or exposed weaknesses in a weapon system during OT&E could then result in a negative Milestone III decision and cancellation of the program. Captain Mills made specific recommendations for each of the five identified problem areas.

a. Test Schedules

Captain Mills concluded that pre-established schedules drive the tests, and not system readiness for the testing. "Instead of testing a system when it is ready, the tendency is to test the system when it is scheduled." [Ref. 37:p. 71] The following specific recommendations for improving test scheduling were given [Ref. 37:p. 74].

- Test schedules should have some flexibility to allow for delays caused by training, equipment, instrumentation and weather problems.
- Unplanned, additional testing requirements should not be added to the test schedule.
- Test schedules should be established on the basis of systems readiness, rather than strictly on milestones.
- Sufficient time should be planned in the schedule for system maintenance and recovery after DT&E.

b. Technical Manuals

Technical Manuals (TMs) are an integral part of system/equipment support requirements. Captain Mills concluded that early attention to technical manuals can result in a more accurate product and led to fewer logistical support problems during OT&E. [Ref. 37:p. 71] His specific recommendation for improving TMs is, "contractor technical writers should be brought to the training and testing locations to correct TM's as problems are noted by the users." [Ref. 37:p. 74]

c. Test Reports

Captain Mills stated, "...operational test reports lack consistency and completeness in their depth of coverage." [Ref. 37:p. 72] The lack of coverage leads to reports that do not clearly report what actually happened in testing, and limit their usefulness to decision-makers and PMs. The specific recommendation for test reports is that they contain information as to what actually happened in testing. [Ref. 37:p. 74]

d. Test Resources

Test resource issues where determined to be the majority of the problems which occurred during OT&E. [Ref. 37:p. 72] Some of the specific recommendations to improve test resource issues were as follows [Ref. 37:pp. 74-75]:

- Sufficient test articles should be produced and available well before the operational test is supposed to start.
- Systems should go through burn-in prior to the operational test.
- Test sites should be adequate in size, and all special clearances should be obtained.
- Test instrumentation should not interfere with user operations.
- All necessary support equipment should be available and operable.
- All weapons effects simulators should be tested and judged to be realistic and effective prior to the tests.

- Detailed memorandums of Understanding (MOUs) should be executed with all military units providing test support personnel.

- OT&E should be restricted to a reasonable duration.

e. User Experience Training

Captain Mills' final conclusion was that, "user experience training and testing before the operational test is extremely valuable to the Program Manager and his system." [Ref. 37:p. 73] Early user training ensures that problems are discovered prior to testing, and that users gain realistic experience with the system before they are evaluated. The specific recommendations to improve user experience training were [Ref. 37:p. 76]:

- The Program Manager should schedule Force Development testing and training prior to IOT&E.

- Training should not be conducted too early, since there may not be sufficient production representative systems available to support the training, and users may forget the training.

- Prototypes of detailed mock-ups need to be available for all training conducted before OT&E.

O. CHAPTER SUMMARY

This chapter defined test and evaluation, explained the various types of test and evaluation conducted in the DoD acquisition cycle, and presented previous test and evaluation lessons learned from other Major Defense Acquisition Programs. The chapter serves as background for the following chapter on the AAAV Program's test and evaluation strategy.

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V. AAAV TEST AND EVALUATION STRATEGY

A. INTRODUCTION

The purpose of this chapter is to establish and document the evolution of the AAAV PMO's test and evaluation strategy from Milestone 0 to the present, and document the anticipated strategy for the future. The chapter will begin by providing an overview of the AAAV PMO structure and its general acquisition strategy to date. It will then establish the evolution of the PMO's test and evaluation strategy by analyzing three versions of the Test and Evaluation Master Plan covering an eleven-year period. The chapter will conclude with an overview of the Program's requirements development and reconciliation process, the results of which serve as a basis for vehicle performance evaluation. This chapter provides the foundation for the development and analysis of test and evaluation issues faced by the PMO covered in the following chapter.

B. AAAV PROGRAM ORGANIZATION

The AAAV program was first initiated in June 1985 when the Naval Sea Systems Command established the Marine Corps Assault Amphibious Vehicle Program Office (NAVSEA PMS-310). According to Acquisition Plan NAVSEA 88-043 Revision 1 (89), the AAAV program, "...is intended to design, develop, and field a cost-effective, state of the art system of AAAV's to replace the existing AAV7A1 series of amphibians." [Ref. 40:p. 1] At the time the AAAV was seen as:

> ...a high water speed armored amphibian vehicle capable of independent operations in water and on land. It will provide one of the principle means of tactical surface mobility, armored protection, and offensive firepower

> for the landing force during the ship-to-shore phase of amphibious operations and subsequent combat operations ashore. [Ref. 40:p. 1]

As seen in Figure 9, the reporting chain for the PMS-310 AAAV program manager was complex.

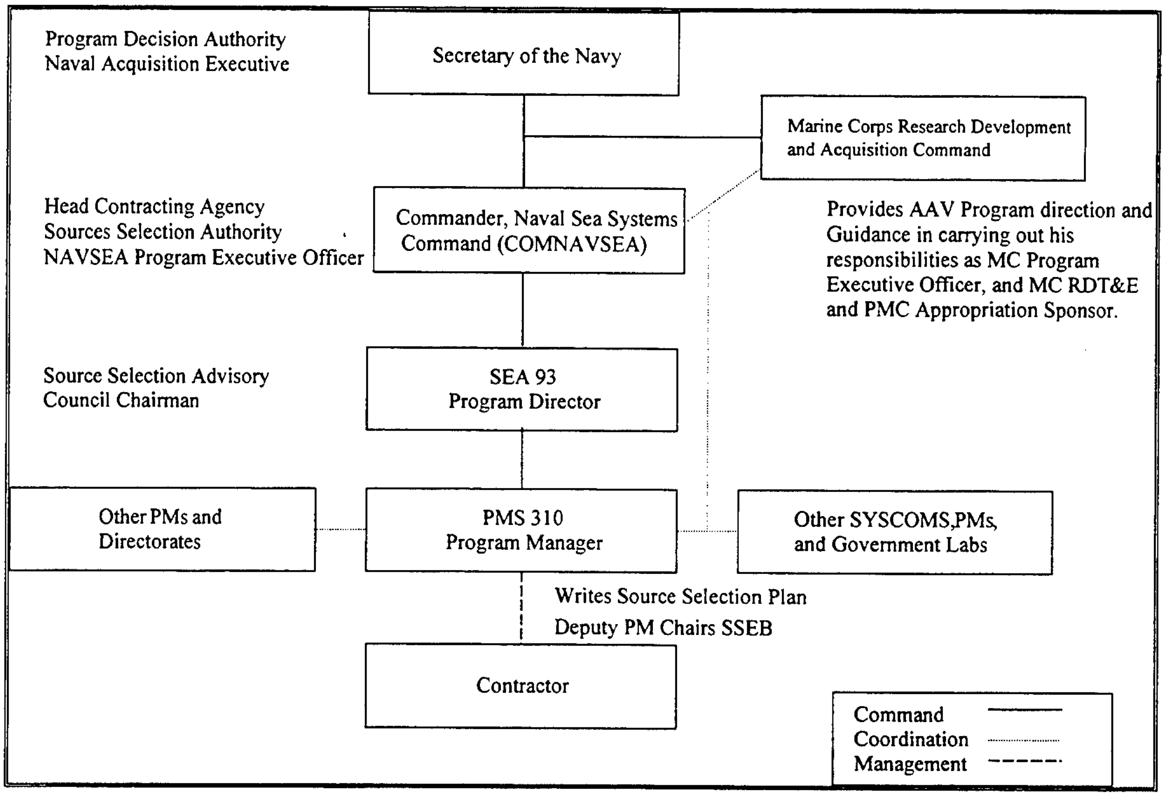

Figure 9. PMS-310 AAA Program Acquisition Relationship. [Ref. 41]

In 1990, the Department of the Navy consolidated various Marine Corps Assault Amphibian resources from NAVSEA and the Marine Corps Research, Development and Acquisition Command (MCRDAC) into a single AAAV program office. [Ref. 42:p.1] The former PMAAV became designated the Direct Reporting Program Manager (DRPM) for Advanced Amphibious Assault (AAA). As a result, the DRPM AAA now reports directly to the Assistant Secretary of the Navy (Research, Development, and Acquisition), "who serves as the Naval Acquisition Executive (NAE), on all matters of cost, schedule, and performance of assigned programs." [Ref. 42:p. 4] Command, coordination, and support relationships at the time of reorganization can be seen in Figure 10. The relationship remains the same with the exception that MCRDAC is now designated Marine Corps Systems Command (MARCORSYSCOM).

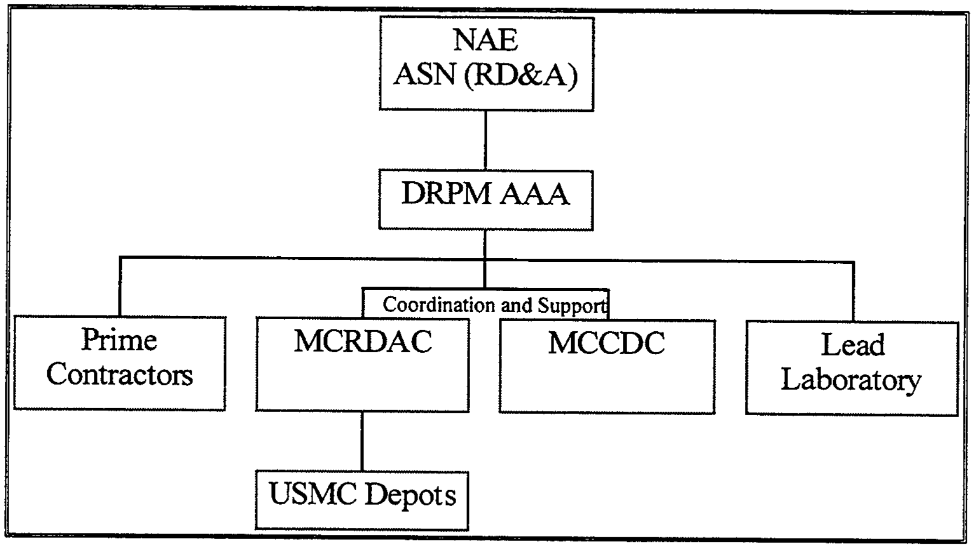

Figure 10. DRMP AAA Acquisition Relationship. [Ref. 42:Encl. 2]

At the time of the consolidation, the DRPM AAA became responsible for the following five programs: Assault Amphibious Vehicles (AAV7A1 Family), AAV Product Improvements (AAV7A1 PIP), Advanced Amphibious Assault (AAA), Stratified Charged Rotary Engine (SCRE), and Marine Corps Assault Vehicles (Engineering). [Ref. 42:Encl. 1] In 1993, the Program was again reorganized with the break out and shifting of AAV7A1 responsibilities to the PM AAV who reports to MARCORSYSCOM. [Ref. 43]

With respect to internal organization, the DRPM AAA employs approximately 70 military and civilian government workers. The Deputy Program Manager, Mr. Walter Zeitfuss (GS-15) assists the DRPM, Colonel Blake Robertson, in the conduct of his duties. The program management office (PMO) is divided into six divisions with the following supervisors [Ref. 44]:

- Director, AAAV Systems (GS-15).
- Director of Engineering (GS-15).
- Director of Logistics (GS-15).
- Director, Test and Evaluation, Operations, and Plans (Lt Col)
- Director of Business and Finance (GS-15).
- Director of Cost Estimation and Procurement (GS-14).

A detailed organizational diagram can be found in Appendix A.

Following the Secretary of Defense's guidance on streamlining acquisition, the DRPM AAA stipulated in the Product Definition and Risk Reduction (PDRR) Phase Request for Proposal (RFP) that the program office and the contractor would co-locate and use an Integrated Product Process Development (IPPD) approach to system development. In June 1996, General Dynamics was awarded the contract for the PDRR phase. They then purchased and occupied a facility in Woodbridge, Virginia that now houses both the DRPM AAA offices and the General Dynamics Amphibious Systems (GDAMS) division of General Dynamic Land Systems. The co-location greatly facilitates the use of the IPPD's Integrated Product Team (IPT) concept. [Ref. 45:p. 30]

Captain Travis L. Sutton did extensive research on the DRPM's use of IPTs in his March 1998 Master's Thesis titled Investigation of IPPD: A Case Study of the Marine Corps AAAV. In that thesis he quotes then DRPM, Colonel James Feigley:

> My expectation of collocation was the absolute need to cut down cycle time from problem identification to problem resolution... So by bringing them [Government and Contractor] together, my expectation was to create an atmosphere of mutual respect by being able to live and work together, and exposing people to the realities of each other's culture. [Ref. 45:pp. 30-31]

The reduction in decision cycle time is achieved through the use of 28 Program IPTs that are formed along four levels equating to the Work Breakdown Structure (WBS). Captain Sutton describes the four levels as follows [Ref. 45:pp. 31-33]:

- The "A" level team deals with major program and cost issues and consists of the Executive Management Team (EMT) – DRPM, Vice-President of GDAMS, as well as Program Management Team (PMT) level "B" team leaders.

- The "B" level teams (i.e. PMTs) are responsible for project management, systems integration, test and evaluation, and production design. They maintain control over trade-off issues.

- The "C" level teams monitor and control discrete performance parameters of the vehicle, such as firepower or mobility. The level "C" items are then delegated down to the individual work package level that are performed by "D" level IPT's.

Colonel Feigley directed that, "all IPTs are contractor-led with Government participation." [Ref. 45:p. 33] See Appendix B for a detailed breakdown of the 28 DRPM AAA Program-level IPTs.

The AAAV program oversight is also conducted through an IPT process. At the highest level is the Overarching IPT (O-IPT). The O-IPT serves to provide assistance, oversight, and review while the AAAV program progresses through the life-cycle process. The O-IPT is led by the Office of the Under Secretary of Defense Acquisition and Technology's Director of Strategic and Tactical Systems (DS&TS) and his Deputy Director for Land Warfare. Additional members include the DRPM, ASN(RD&A) and staff, USD(A&T) and staff, and relevant OSD staff principles. [Ref. 46]

Following the March 1995 Milestone I decision, the DRPM AAA initiated an "Integrating" IPT (I-IPT) that served temporarily in lieu of the Overarching IPT, but now serves to support, "the development of strategies for acquisition and contracts, cost estimates, evaluation of alternatives, logistics management, cost-performance trade-offs, etc." [Ref. 46] The purpose of the Integrating IPT is, "to focus its efforts on developing strategies, reviewing program progress, and identifying and resolving issues." [Ref. 47:p. 2] The Integrating IPT is chaired by the DRPM and the USD((A&T)DDLW) while membership includes the Deputy PM, one ASN(RD&A) representative, 12 OSD Staff representatives from various divisions, and one Joint Staff representative. [Ref. 47:Encl. 2] The goal of both the O-IPT and the I-IPT is to resolve the majority of issues at the lowest level and to only escalate those issues that require resolution at a higher level. The I-IPT is also responsible for coordinating the effort of three Working-IPTs (Test and Evaluation, Cost/Performance, and Modeling and Simulation). [Ref. 46]

The DRPM AAA has delegated test and evaluation authority to his Director, Test and Evaluation, a subordinate to the Director, Test and Evaluation, Operations, and Plans.

By organization, the T&E Manager has three subordinate Civilian test billets to assist him. The T&E Manager's duties are outlined as follows [Ref. 78]:

- Responsible for preparing and coordinating USMC, Department of Navy and Department of Defense approval of the AAAV Test & Evaluation Master Plan (TEMP).

- Chair of Integrated Process Team (IPT) for T&E with members from MCOTEA, MCCDC, ASN(RD&A), and DoD Test and Evaluation (T&E) agencies.

- Participates as USMC representative for all contractor developmental test planning.

- Manages Program Office T&E budget for conduct of developmental and operational testing.

- Negotiates support requirements with DoD Major Range and Test Base Facilities (MRTBF) where AAAV will be tested.

- Officer in Charge (OIC) for 9 enlisted Marines assigned to program office as test crewmen for AAAV prototypes.

The T&E Manager is also responsible for heading the DRPM's Test and Evaluation Working IPT (WIPT). The first T&E WIPT was held on 26 March 1997 and discussed the purpose, focus and intent of the WIPT. The WIPT also discussed detailed issues with respect to live-fire T&E, DT, Safety testing, firepower accuracy testing, and modeling and simulations. [Ref. 48] The DRPM's Test and Evaluation Master Plan describes the T&E WIPT's purpose as, "to identify, address, communicate, and resolve interagency test issues and concerns." [Ref. 57] Membership of the T&E WIPT includes representatives from DRPM, DS&TS, DOT&E, DOT&E(Live-Fire Test), MCCDC, MCOTEA, and AVTB. [Ref. 51]

GDAMS Test and Evaluation Manager heads the Program "B" Level Test and Evaluation IPT. The Test IPT Charter states, "The Test and Evaluation IPT will plan, conduct and support system, subsystem and component testing as necessary to verify AAAV design compliance with System/Subsystem Specification performance requirements." [Ref. 49] Additionally, the DRPM's 1999 Draft TEMP states, "The Program T&E IPT is responsible for developing instrumentation plans, detailed test plans, and support plans." [Ref. 57] Because test and evaluation crosses most organizational lines, GDAMS stipulates that the Test IPT will consist of personnel, "that have a direct link to the completion of tasks associated with 'validation' of designs/process." [Ref. 50:p. 5] Presently the Test IPT includes members from the following sections: DRPM AAA, Mobility, C4I, Firepower, Integration and Assembly, Logistics, Specialty Engineering, Structures and Auxiliary Systems, Test and Evaluation, Systems Engineering, and Project Management. [Ref. 52]

While initiating the Test IPT, GDAMS and the DRPM determined that the IPT be responsible for establishing how the following issues would be handled [Ref. 50]:

- IPT operation methodology.
- Method of reporting classified test information to pertinent personnel.
- Determination whether System/Subsystem Specification N/A's are truly N/A.
- Determine what portions of referenced test documents apply to AAAV program.
- Coordination of test site/facility usage.

- Development of test plans and reports.
- Develop the requirements for system test instrumentation.
- Support for AAAV System "Safety Release".
- Corrective action team support.
- Dissemination, cataloging, and maintaining the library of test reports and data.
- Identify and monitor the major risk elements for test.
- Impacts of vehicle build options on the test program.
- Personnel and supply support requirements for test.
- Interfaces with other government agencies.
- Test site security requirements.
- Reporting/handling of vendor proprietary test information.

In addition, the Test IPT is also responsible for establishing the criteria and requirements for the following critical items [Ref. 50]:

- Reporting of Safety Incidents, Accidents, and Fires.
- Acceptable vehicle down time during test.
- Cannibalization allowed to continue test.
- Maintenance activities allowed without IPT approval.
- Maintenance activities during qualification test that causes complete retest.
- Test thresholds needed during test.
- Decision authority to <u>Start</u> and <u>End</u> a test.

- Safety requirements for test operations in conjunction with the testing agency.
- Vendor test needs.
- Qualification test needs.
- Use of qualification test assets to support system test.
- Tailoring of tests to meet program needs.

C. AAAV ACQUISITION STRATEGY

The evolution of the AAAV acquisition strategy began even before the establishment of the PMAAV office PMS-310. The Marine Corps first began to examine follow-on capabilities to the LVT7 in 1971. This led to the establishment of the Landing Vehicle Assault (LVA) program requirements in 1973. [Ref. 53] The program's focus was on developing a high-water speed capable vehicle that could also function in high-speed on land. The program was cancelled in 1979 by the Commandant of the Marine Corps for "vulnerability, affordability, and maintainability" concerns. [Ref. 3:pp. 21-21] The lesson derived from the LVA program was that, "significant gains without a solid technological foundation leads to prohibitive costs and unacceptable risk." [Ref. 54]

The acquisition of a replacement vehicle continued with the selection of the Landing Vehicle Tracked – Experimental (LVT(X)) over the LVA. This vehicle was a slow speed amphibian that was to meet the needs of new requirements. The development of the LVT(X) continued until questions arose about its ability to meet even newer developing OTH requirements. The program was cancelled in 1985 when the Secretary of the Navy determined that, "the marginal improvements in firepower and armor in the

LVT(X) compared with the LVTP7A1 were not worth the estimated $9B cost of the new program." [Ref. 3:p. 24] The lesson from the LVT(X) program was that, "significant investments without significant gains make no sense." [Ref. 54]

The lessons from these two program cancellations shaped the acquisition strategy of the PMAAV. PMS-310's initial Acquisition Plan NAVSEA 88-043 and the DRPM's updated Acquisition Plan 90-002 followed the traditional acquisition approach of methodically progressing through each phase in preparation for the next milestone. The DRPM's acquisition strategy of 1991 even states:

> The overall development strategy for the AAAV follows the traditional approach to the DoD Life Cycle Systems Management Model in that all development phases will be executed in sequence (Concept Exploration/Definition (CE/D), Concept Demonstration/Validation (CD/V) [DemVal], and Full Scale Development (FSD)). At each program milestone, proposals for the next acquisition phase will be evaluated with the preferred designs proceeding into the next phase. [Ref. 55]

The referenced phases equate to the present day CE, PDRR, and EMD phases respectively.

The lessons also drove the Marine Corps to establish a Technology Base Development Program in 1985. [Ref. 54] This Technology Base Development Program served to enhance high-water speed capabilities and reduce risk associated with those capabilities. By 1990, the DRPM had began applying the following seven-step approach to the Technology Base Development Program [Ref. 54]:

- Target the "High Drivers" of affordability, risk, and performance for development.

- Develop each subsystem in a competitive environment.

- Systematically integrate groups of technologies in successively more complex test beds - and test.

- Culminate the Technology Base Program by integrating all subsystems into an "all-up" advanced technology transition demonstrator - and test.

- Apply selected Technology Base Developments to the current system and test.

- Do it all before deciding upon an amphibious vehicle concept.

- Make everything (successes and failures) available to industry in total (DTIC) [Defense Technical Information Center].

In 1993, the DRPM AAA convinced the Deputy Secretary of Defense, Dr. Perry, and the USD(A&T) that an "evolutionary acquisition strategy" would allow the Marine Corps to field the AAAV five years earlier than the current Acquisition Program Baseline (APB). [Ref. 3:pp. 66-68] The underlying concepts to the AAAV's evolutionary acquisition strategy are analyzed in detail by LtCol Scott Adams in his thesis, A Case Study of the Advanced Amphibious Assault Vehicle (AAAV) Program from a Program Manager's Perspective of March 1999. LtCol Adams determined that the following program management office (PMO) decisions have been critical in the development of the current acquisition strategy [Ref. 3:pp. 130-132]:

- Initiation of risk-reduction projects during the CE phase, which resulted in a technically complex amphibious vehicle having no risk area rated higher than moderate at the MS I Review.

- Conduct of two Early Operational Assessments during the CE phase, which provided the user the opportunity to evaluate each contractor's preliminary vehicle design very early in the design phase.

- Adoption of an evolutionary acquisition strategy, which will allow the contractor to focus on developing the core capabilities of the AAAV. The remaining capabilities will be incorporated later when the technology is available.

- Down-selection to one contractor for the PDRR phase, which allowed the Government to impart all of its knowledge on amphibious vehicles to just one contractor and save an estimated $190M in the PDRR phase.

- Use of a CPAF [Cost Plus Award Fee] contract during the PDRR phase, which incentivizes the contractor to control costs and also provides the PM with the means to focus the contractor's developmental efforts on specific areas throughout the PDRR phase.

- Inclusion of the AAAV Special Design Decision provision in the PDRR contract, which gives the contractor an added financial incentive to conduct realistic trade studies.

- Prevention of contractor "buy-in" by showing each contractor the Government's cost estimate on their proposal for the PDRR phase, which resulted in each contractor increasing their proposed price by $40M.

- Mandating the physical co-location of Government and key contractor employees, which allowed the PM to achieve the cultural change he wanted and to implement the acquisition reform initiatives he sought.

- Requiring the use of IPPD and IPT, which results in quicker resolution to problems.

The most current acquisition plan, DRPM AAA 96-1 Revision 2, identifies five acquisition-streamlining initiatives applicable to the acquisition strategy. Of the five, three represent the most impact on the test and evaluation strategy. The program, "will use NDI [Non-Developmental Items] as much as possible in order to economize on development costs and take advantage of economies of scale." [Ref. 56:p. 13] The Demonstration & Validation Phase may include, "...the acquisition of additional material and services related to the D&V phase from selected D&V contractor, e.g., up to two additional full system prototypes and related materials and services." [Ref. 56:p. 13] Finally, "...instead of developing and fabricating a separate AAAV(C) prototype, the base D&V contract will require development and fabrication of only the communications suite for the AAAV(C) variant." [Ref. 56:p. 13]

As the DRPM progresses toward his goal of producing 1013 vehicles, including 935 personnel carriers and 78 command variants, his mission remains to "design, develop, and field a cost-effective, state-of-the-art system to replace the existing AAV7A1 series of amphibians." [Ref. 56]

D. EVOLUTION OF AAAV TEST AND EVALUATION STRATEGY

This section examines the evolution of the PMO's test and evaluation strategy over an eleven year period by drawing primarily from three Test and Evaluation Master Plans (TEMPs) with supplementary input from Acquisition Plans, Acquisition Program Baselines (APBs), Program presentation briefing slides, test reports, and the 1995 Integrated Program Summary.

1. Test Management

A 4 November 1988 draft copy of the initial TEMP indicates that test management would be divided into three areas. First, the contractor would be responsible for the conduct of their testing prior to governmental acceptance of the system. The contractor's testing would be performed at contractor facilities, "if adequate", with test plans written by the contractor and approved by the government. [Ref. 58:p. 9] PMS-310 directed that the contractor submit recommended Detailed Test and Evaluation Program Plans for both Developmental Testing and Operational Testing. [Ref. 58:p. 9] PMS-310 further directed that the contractor be responsible for, "the operations and all necessary test support to include, but not be limited to, maintenance, transportation, data, and instrumentation." [Ref. 58:p. 9]

Second, MCOTEA was tasked with responsibility for ensuring that, "operational testing is effectively planned, conducted and evaluated," and for ensuring that the Independent Evaluation Report of test results was written and submitted. [Ref. 58:p. 9] Finally, the program office was responsible for, "planning, conducting, and reporting all DT&E prior to full scale production." [Ref. 58:p. 9]

The DRPM AAA's initial TEMP was first submitted for approval in July 1994, but was returned by DOT&E and DTSE&E because of a Milestone I date change. The DRPM's initial TEMP was finally approved on 6 March 1995. The 1995 TEMP specifically states that, "Testing follows a classical acquisition approach with dedicated and separate testing for DT/OT." [Ref. 59:p. II-1] Though the TEMP does concede that opportunities for concurrent DT/OT testing at remote locations may exist.

The 1995 TEMP breaks the test management responsibilities into generally the same three categories as the 1988 Draft TEMP. The DRPM AAA is responsible planning, conducting, and reporting all DT&E, while "executing broad responsibility for the implementation of policies, procedures and requirements for developmental testing and evaluation." [Ref. 59:p. II-1] MCOTEA is still responsible for the effective planning, conduct, and evaluation of operational testing. The 1995 TEMP adds responsibility to MCCDC for ensuring that input to the system's development comes from the "User/Fleet Marine Force." [Ref. 59:p. II-1]

The contractor's responsibilities again include the conduct of acceptance testing at adequate contractor facilities under contractor submitted and government approved plans. The contractor is still to submit recommended T&E Program plans for DT so that unnecessary duplicate government testing does not occur. However, there in no mention of the contractor submitting recommendations for OT plans. Other differences in the 1995 TEMP include more specific delineation of operation and maintenance duties, and test plan responsibilities. Specifically,

> Contractor and Marine Corps personnel will participate in vehicle operation and system maintenance actions during all developmental testing periods (DT-I, DT-II, and IPT). Intermediate and depot level maintenance support will be provided by the contractor during EOAs. [Ref. 59:p. II-1]

The TEMP also states, "DT/OT will be conducted by the Government in accordance with the Detailed Test Plans (prepared by the Government)." [Ref. 59:p. II-1]

As the PMO prepares for the Milestone II review, the TEMP is undergoing revision. The 30 August 1999 draft version is considered to be a near-final draft with only minor editorial corrections remaining. In contrast to the 1995 TEMP, the 1999 Draft TEMP states, "The AAAV program will pursue a streamlined acquisition approach...Testing is being integrated to the widest extent possible utilizing a teaming approach between the Government and the Contractor." [Ref. 57:p. II-1] Though the

DRPM retains oversight responsibility and remains the final decision authority, both the government and the contractor are responsible for test program planning and execution. [Ref. 57:p. II-1] The intent is to minimize and eliminate repetitive testing by both the government and the contractor.

The 1999 Draft TEMP makes significant changes that pursue the DRPM's team concept. Otherwise distinct duties between the contractor and government now overlap, and previous government responsibilities now rest with the contractor. Marine participation increases through out the DT test phase for both operations and maintenance, with the intent of the DRPM Marines' participation being to increase training in preparation for the EOA and to provide early and continuous user feedback on vehicle performance. DRPM AAA now plans to use Government Test Facilities to the maximum extent possible where as contractor owned facilities "may be considered." [Ref. 57:p. II-1] The 1999 Draft TEMP identifies and expands membership duties and responsibilities for both the T&E Working IPT (WIPT) and the Program T&E IPT (Test IPT). Under that listing, the contractor, not the government, has responsibility for developing detailed test plans for developmental testing. [Ref. 57:p. II-7] As before, MCOTEA remains responsible for operational testing. See Appendix C for a listing of each IPT member's test and evaluation responsibilities.

2. Concept Exploration Phase

Test and evaluation strategy in the Concept Exploration Phase was shaped by two key events. First, the Acquisition Decision Memorandum that approved entry into the CE

Phase directed the Program Management Office to expand its focus in the following three areas [Ref. 60:p. 1]:

- Examine all alternatives of placing infantry ashore, not just a new amphibious vehicle.
- Explore standardization with the Army's Armored Family of Vehicles (AFV) program.
- Revalidate the Landing Craft Air Cushion (LCAC) Acquisition objective.

Second, the Assistant Secretary of the Navy (Research, Development and Acquisition) recommended in 1991, "...that the program conduct an independent technical risk assessment prior to moving further through the Milestone I DAB process, due to the perceived technical risks associated with a new AAAV." [Ref. 61] The Office of Naval Research's (ONR) Office of Advanced Technology (OAT) eventually conducted independent technical risk assessments in 1991, 1992, and 1994. [Ref. 62]

In response to these key events, the PMO established a two part CE Phase Strategy. Part One involved defining the problem and exploring alternatives. The problem was defined as being able to, "provide high speed transport of embarked Marine Infantry from ships located beyond the horizon, to inland objectives...[and] provide protected land mobility and direct fire support during combat operations ashore." [Ref. 63] The crux of Part One was a three-year Cost and Operational Effectiveness Analysis (COEA) of thirteen candidate systems that eventually determined the AAAV to be the best alternative. [Ref. 63]

Part Two of the CE Phase strategy was to exploit the Technology Base in order to reduce the risk associated with the preferred alternative. [Ref. 63] The test and evaluation strategy dealt mainly with Part Two. The strategy focused on systematically integrating and testing groups of technologies in successively more complex test beds, and then integrating all subsystems into an "all-up" advanced technology transition demonstrator for testing. [Ref. 54]

Government developmental testing during this phase was a continuation of the previously established Technology Base Demonstration Program being conducted by the Carderock Division of the Naval Surface Warfare Center, and the David Taylor Research Center. The testing concept followed a progression in technology, size, and complexity. The first test article was an automotive test rig (ATR) used for proving integration of advanced automotive drive train concepts. [Ref. 64] A 0.55 scale High Speed Amphibian and a High Water Speed Technology Demonstrator (HWSTD) were developed next. The HWSTD combined automotive and hydrodynamic components into a single vehicle in order to demonstrate the hydrodynamic feasibility of a planing hull concept. [Ref. 65:p. 6] Centerline magazine states,

> The 17 ton HWSTD became the first tracked vehicle to attain a water speed greater than 25 mph...Although not a full combat sized vehicle..., the HWSTD proved that various high technology components could effectively be integrated to produce a vehicle that could operate as a tracked vehicle on land and achieve over 20 mph in the water. [Ref. 64:p. 12]

The final test article developed by the government was the Propulsion System Demonstrator (PSD). Prior to PSD fabrication, scale models of the HWSTD were modified to represent the PSD design at a 0.245 scale. This model was subject to several hundred hours of testing in the NSWC's David Taylor Model Basin, Deep Water Carriage 2 facility. These tow tank experiments examined vehicle design capabilities in both calm and sea state 2 conditions. [Ref. 65:p. 8]

The actual PSD was build by AAI Corporation and represented a near-scale tracked vehicle, crewed by 3 people, capable of carrying 15 embarked troops, that performed as a planing craft during waterborne operations. The PSD was propelled through the water with a gas turbine engine that provided sufficient thrust to get the vehicle on plane after it deployed a double angled bow plane and chine plates that covered the retractable suspension system. [Ref. 65:p.6] On land, the bow plane and chine plates were retracted, the suspension system lowered, and the power provided by a diesel engine. [Ref. 65:p.6]

The PSD underwent land mode acceptance testing in May 1991 and then combined contractor acceptance tests and government hydrodynamic evaluations in June 1991. [Ref. 65:p. 2] These initial water tests were conducted at the Special Trials Units (STU) located at the Patuxent River Naval Air Station, Maryland. The PSD attained a maximum high water speed of 33 mph (28.5 knots) at the STU on 4 March 1992. [Ref. 65:p. 4] Then in July 1992, the PSD was shipped to AVTB, Camp Pendleton, California for hydrodynamic testing to, "demonstrate open ocean characteristics, operational suitability features and Marine Corps personnel evaluations." [Ref. 65:p. 2] On 17 August 1992, the PSD attained 11.5 nautical miles while on plane. However, in

September 1992 the PSD failed to demonstrate surf transit capability because of seawater intrusion to electrical boxes, which caused coolant louvers to open, allowing seawater to flood the engine compartment. [Ref. 65:p. 4] Testing was suspended until rebuild was complete in 1993. During break-in tests of the rebuilt vehicle, a catastrophic failure to the turbine power section occurred which resulted in cancellation of all further PSD testing. [Ref. 65:p. 4] Despite these setbacks, "The PSD has demonstrated within a three year test effort, the land mobility equivalent to an M1A1 Tank, over water speeds greater than 25 knots and the internal space/payload required for carrying troops." [Ref. 65:p. 2]

Based on the OAT's risk reduction recommendation to "Demonstrate all high risk technologies, particularly the high power density engine, prior to full-scale prototyping," DRPM AAA let contracts to General Dynamics (GD) and United Defense Limited Partnership (UDLP) in 1991. These risk reduction contracts directed the contractors to conduct technical risk-reducing experiments and activities that focused on all identified areas of technical risk including [Ref. 61:p. 1]:

- Fabrication and testing of near full-scale hydrodynamic test rigs.
- Weight reduction programs.
- Prototype waterjet fabrication and testing.
- Fabrication and live-fire testing of armor solutions.
- Extensive vehicle hydrodynamic analysis.
- Appendage robustness testing and analysis.

In 1993, the DRPM let additional contracts to UDLP and GD for full-scale automotive test rigs to evaluate each contractor's AAAV land mobility performance, and land mobility subsystem maintainability and durability. [Ref. 62] Additionally, the 1995 TEMP states that, "A reliable, retractable suspension system has never been developed and fielded and this is a programmatic area of concern." [Ref. 59:p. III-6] Table 3 shows a break out of the test and analysis efforts by each contractor during the CE Phase whether completed or in progress at the time of the Milestone I decision.

United Defense Limited Partnership	General Dynamics Land Systems
Hydrodynamic Test Rig (0.75 scale)	Hydrodynamic Test Rig (0.8 scale)
Full Scale Appendage Actuation	Hydrodynamic Model Testing (1/8 scale)
Composite and Armor Repair	Composite Integration
Crew Station Analysis	Armor Repair and Ballistic Evaluation
Electronic Motor Efficiency/Cooling	Waterjet Design and Analysis
Hydrodynamic Model Testing	Automotive Test Rig
Automotive Test Rig	

Table 3. AAAV CE Phase Contractor Test and Analysis Efforts. [Ref. 59:p. III-3]

The DRPM used full-scale mock-ups of each contractor's proposed personnel variant design to conduct two technical assessments, or user juries, by Fleet Marine Force operators and maintenance personnel. The users provided insight on the mock-ups technical, safety, training, maintenance, and human factor issues of the proposed design. [Ref. 59:p. III-2]

In addition to the technical assessments, MCOTEA conducted two EOAs on the contractor's mock-ups. The EOAs addressed survivability, maintainability, human factors and safety, and passenger capacity operational issues. [Ref. 59:pp. IV-3,4] The 1995 TEMP provides the following specifics:

- Survivability. The EOA partially assessed the placement of machinery, fuel, and ammunition to enhance survivability and personnel protection. The EOA assessed whether the AAAV(P) presents a lower silhouette/height than the AAVP7A1 for reduced susceptibility. The EOA partially assessed the AAAV(P)'s ability to generate smoke for self or area obscuration. [Ref. 59:p. IV-3]

- Maintainability. The EOA partially assessed system design, layout, and built-in test/built-in test equipment to determine if the AAAV(P) exhibits any detrimental maintainability characteristics. [Ref. 59:p. IV-3]

- Human Factors and Safety. The EOA partially assessed displays, controls, equipment design and layout, crew access, and safety to determine if the AAAV exhibits any detrimental human factors and safety characteristics. [Ref. 59:p. IV-4]

- Passenger Capacity. The EOA fully assessed the AAAV(P)'s passenger capacity to determine if the system could accommodate a reinforced Marine rifle squad equipped for combat. [Ref. 59:p. IV-4]

- Other Issues. The EOA also partially assessed other operational effectiveness and suitability issues such as:

  - Crew and passenger ingress/egress; weapon(s) field of fire; and crew field of view.

  - Operator training; maintenance personnel training; AAAV(P) crew size; and special tools/support equipment. [Ref. 59:p. IV-4]

The DRPM's risk reducing efforts throughout the CE Phase resulted in the following conclusions by the ONP's independent technical assessment in 1992:

> The OAT independent "Red Team" assessments of the AAAV program were valuable in causing programmatic action to mitigate and eliminate technical risks in the AAAV designs and in the program. All areas of technical risk identified as "high" have been reduced to moderate, low or have been eliminated. Many moderate risks have been reduced to low or have been eliminated. Current assessments are that the AAAV design will

> meet all operational requirements with acceptable levels of technical risk, so no operational requirement revisions are planned. [Ref. 61:p.3]

The OAT's 1994 assessment reached the same conclusion, and again no high-risk areas were identified. The OAT recommended that the program begin Full Scale Prototype Fabrication and entry into the next phase. [Ref. 62]

In a memorandum for the Chairman, Conventional Systems Committee, the Director, Test, Systems Engineering, and Evaluation states that, "Based on our review of the AAAV program technical status, we feel it is ready to enter the demonstration/validation [PDRR] phase." [Ref. 66] The memorandum indicates that there are no outstanding issues with the 1995 TEMP, that the program office has identified the key risk areas and adequately addressed them in their test program, that the program has demonstrated satisfactory DT performance to date, and that the program has adequate DT plans in place for the next phase of testing. [Ref. 66:pp. 8-9] With respect to the test program the memorandum indicates the following three distinguishing features worth noting [Ref. 66:p. 8]:

- It makes good use of Army combat vehicle technologies including test ranges and facilities.

- It has a very thorough set of technical performance parameters (about 60), that provide clear performance objectives and thresholds for each phase of the test program.

- It provides sufficient time for all development testing, and there is no test concurrency with operational testing.

The DRPM's assessment of the AAAV to the Acquisition Review Board in 1994 was that, "[The] AAAV is very technically mature for the C/E Phase..." [Ref. 67]

3. Program Definition and Risk Reduction Phase

The purpose and goals of the program's test and evaluation strategy for the PDRR Phase remained relatively stable from 1988 to the present. However, the conduct of that strategy was heavily influenced by the decision to down-select to one contractor for the PDRR Phase, a revision of the AAAV Command and Control Variant's requirements, and fluctuating funding levels.

First, the DRPM's decision to down-select to one contractor in the PDRR Phase initially meant that the conduct of testing would be simplified because the number of test articles would be reduced from two to one.

Second, in January 1997, the Commanding General, Marine Corps Combat Development Command (MCCDC) issued an update to the command, control, communications, computers, and intelligence (C4I) requirements for the AAAV(C) variant. The updated requirements were described in a new concept of employment. [Ref. 68] The DRPM initially based his development plan for the AAAV(C) around the requirements to simply use the existing AAVC7A1 communications equipment. However, the new concept of employment called for a mobile amphibious and land forward command post (CP) capability with computer workstations. Based on these new requirements for the AAAV(C), the DRPM stated, "Changes in integration requirements and application deliveries makes previously planned contract work on CP inappropriate...Thus we stopped work on CP part of contract." [Ref. 69] The stop work period consisted of three phases. The first phase involved deriving and defining requirements from the Concept of Employment. The second phase involved assessing the technical feasibility of requirements. The final phase involved determining the impact of the requirements change on the program's integration schedule. This third phase of stop work lasted for approximately 18 months while the DRPM "waited" on other program offices to complete their applications. [Ref. 69]

Third, the funding levels for the AAAV program began to fluctuate significantly with the issuance of Program Decision Memorandum (PDM) 4 in December 1994. The PDM reduced the original FY96-01 funding stream by $190M resulting in a 2+ year stretch out of the original baseline just prior to the Milestone I decision. [Ref. 70] This stretch out of the program was deemed unacceptable by congress and on 30 September 1995, the OSD issued PDM II which added back an additional $107M throughout FY97-01. The DRPM was directed to accelerate the PDRR phase by nine months. [Ref. 71:p. 3] For FY97, the congressional defense committees appropriated an increase of $20M to accelerate the fielding of the AAAV. [Ref. 72] The DRPM's request for the funding stated:

> The $20 million FY 1997 plus-up funding will be applied to highly valuable technical risk reducing projects that are not currently part of the baseline Program Definition and Risk Reduction (PDRR) Phase due to a previously imposed FY1997 funding cap. These projects include further armor development, high water-speed testing, on-the-move weapons station testing, automotive and suspension testing, engine development, an advanced simulation. The projects will lower certain technical uncertainties and mature the PDRR vehicle design, making the fabrication and testing of two additional prototypes more economically feasible, allowing concurrent vehicle testing during PDRR and accelerating the AAAV program Milestone II DAB review by 4 months. [Ref. 73]

The DRPM used the additional funding to procure a second prototype from the contractor, and the Milestone II review was accelerated from April 2001 to January 2001.

In 1997, the DRPM submitted a report the United States House of Representatives' National Security Committee (NSC) on its plan to accelerate the AAAV program. The accelerated strategy is based on adding prototypes to the PDRR testing effort, initiating AAAV manufacturing development earlier, and creating a second delivery of EMD prototypes. [Ref. 74] In a separate request, the DRPM sought $10.041M for FY98 specifically to add one prototype to the PDRR Phase contract. The justification for the request was:

> With only the two currently planned Demonstration and Validation (D&V) prototypes, developmental testing must essentially be conducted in serial fashion, subjecting the test schedule to potential risk of delay if there are significant equipment failures. With an additional prototype, testing activities can be safely conducted in parallel and the impact of significant equipment failures is mitigated. In addition, three prototypes worth of lessons learned from both their fabrication and testing will significantly enhance the maturation of the AAAV design. Another important benefit is that Government engineers and Marine operators can continue to collect important reliability data in parallel with the independent tester's Early Operational Assessment. [Ref. 75]

The 1997 Selected Acquisition Report indicates the program actually received an $8M plus-up for the procurement of the third prototype. [Ref. 76]

In January 1999, the program office requested an additional funding plus-up for $26.4M. This request was justified:

> ...to significantly mitigate technical and schedule risk and position the program for IOC [Initial Operational Capability] acceleration from FY06 to FY05. This Enhancement will allow the AAAV Program the incorporation of changes into the AAAV design based on lessons learned

> from the Program Definition and Risk Reduction (PDRR) Phase integration and assembly of the PDRR prototypes, the PDRR logistics demonstration, and PDRR system developmental and operational testing. The enhancement will also allow...the development of more reliable E&MD phase prototypes...
>
> ...[and] will ensure that the AAAV design incorporates all required changes that address system hardware and software reliability. These reliability changes are critically important to successful operational testing of the AAAV's E&MD prototypes. [Ref. 77]

This plus-up would also help meet the PMO's desire to move the Milestone II review from January 2001 to October 2000. [Ref. 78]

As will be seen, even with the decision to down-select to one contractor for the PDRR Phase, the revision of the AAAV Command and Control Variant's requirements, and fluctuating funding levels, the overall program's test and evaluation strategy for the PDRR Phase remained relatively stable.

The 1988 Draft TEMP outlines the original objectives for the program's Developmental Test and Evaluation efforts. The following questions were to be addressed and answered over three Developmental Test events (DT-I, DT-II, and DT-III) [Ref. 58:p. 14]:

- Is the AAAV compatible with Naval amphibious warfare ships, MPS [Maritime Pre-positioned Shipping] and MSC [Military Sealift Command] ships?
- Does the AAAV demonstrate required mobility when compared to other current and planned combat vehicles with which it will operate during subsequent operations ashore?
- Does the AAAV demonstrate required waterborne mobility to include performance and survival in specified sea states and surf?

- Does the AAAV demonstrate the required capabilities to detect, identify, acquire, engage, and destroy specified targets?

- Does the AAAV provide required survivability?

- Does the AAAV demonstrate required reliability and maintainability and durability characteristics?

- Does the AAAV provide for effective interface with crew/troop/maintenance personnel in the required operational environment?

- Does the AAAV provide for safety consistent with system requirements?

- Does the AAAV provide required ancillary capabilities?

- To what extent does the AAAV provide standardization and inter-operability to maximize commonality?

Specifically for the PDRR Phase, DT-I's purpose was seen as a means to, "demonstrate AAAV technical performance characteristics, determine the feasibility of selected system/subsystem or component technical design, and determine the seriousness of design risks, logistics supportability and life cycle costs." [Ref. 58:p. 15] Each of two contractors were to provide two prototype vehicles for water mobility, land mobility, survivability, firepower, ballistic protection, and combat capability performance testing. Testing by the contractors was planned for three months, while Government planned DT-I testing was scheduled for six months. [Ref. 58:pp. 15-16]

At the completion of DT-I, the contractors would refurbish their vehicles, finish acceptance testing, and then deliver the vehicle to the Government for Operational Test Event-I (OT-I). The purpose of OT-I would be to examine the contractors' vehicle design for operational effectiveness and suitability so that comparisons between the two could be used for down-selection decisions into the next phase. The scope of OT-I was to accumulate 20 hours per vehicle, per month for six months while operating in a realistic environment based on operational mission profiles. [Ref. 58:p. 22]

Acquisition Plan NAVSEA 88-043 Revision 1 (89) specifies only one prototype vehicle per contractor, but is consistent with the 1988 Draft TEMP with respect to DT/OT-I's purpose. The Acquisition Plan states, "In addition to the design effort associated with the personnel variant, each contractor/contractor team will design designated Mission Role Variants (MRVs). These designs together with DT/OT-I test results and updated program documentation will provide the basis for transitioning to Milestone II." [Ref. 40:p. 3] Acquisition Plan DRPM-AAA 90-002 maintains the one vehicle per contractor requirement for PDRR Phase testing and the intent to use the test results for down-selection, but further stipulates the development of an Automotive/ Hydrodynamic Test Rig(s) by the contractor. [Ref. 79:p. 5]

Of note, the 1988 Draft TEMP, Acquisition Plan NAVSEA 88-043 Revision 1 (89) and Acquisition Plan DRPM-AAA 90-002 are the only documents found by the author that reference Mission Role Variants. The 1988 Draft TEMP lists desired capabilities for a personnel mission role variant (AAAV-P), an assault gun mission role variant (AAAV-AG), a command mission role variant (AAAV-C), an engineer mission role variant (AAAV-E), and a recovery mission role variant (AAAV-R). [Ref. 58:pp. 5-6]

All follow-on documents reference only the personnel variant and a command and control variant.

The 1995 TEMP increases in detail its description and objectives of PDRR testing. The TEMP describes the purpose of testing in this phase as, "Apart from demonstrating overall capability as an amphibious assault system in a mission profile based operational scenario, the primary purpose of the D&V prototype will be to reduce program risk through determination of technical deficiencies in sub-systems and operational modes that will be corrected in EMD." [Ref. 59:p. III-1] See Appendix D for the Integrated Test Program Schedule listed in the 1995 TEMP.

The purpose of the 1995 TEMP's DT-I for the AAAV(P) was to confirm the AAAV technical performance characteristics, determine the feasibility of selected system/sub-system or component technical design, determine the degree of design risk, and assess initial logistics supportability for the next milestone decision. [Ref. 59:p. III-7] The TEMP describes the prototype to be tested during DT-I as a pre-production prototype that would be fully functional for land and water mobility, survivability, firepower/lethality, and human factors. [Ref. 59:p. III-6] Additionally, the prototype would be evaluated for its software maturity and Nuclear, Biological, and Chemical (NBC) collective protection. Throughout DT, the prototype would undergo Engineering Evaluation Testing at the highest assembly levels possible. Armor samples would continue to be delivered and tested by both the contractor and the government. [Ref. 59:p. III-7]

The 1995 TEMP identifies the scope and objectives for the AAAV(C) communication suite as evaluating the integration, human factors, and compatibility issues associated with co-located equipment in the AAAV hull. This evaluation would be accomplished by the development of two stationary mock-ups and an operational mock-up retrofit into a modified ATR, or ATR(C). [Ref. 59:p. III-9]

The 1995 TEMP identifies planned live-fire testing during the PDRR Phase as Ballistic Hull and Turret (BHT) fabrication and testing, armor panel testing to the 90% probability of no penetration (P_{NP}), and shot line analysis. The DRPM's goal would be to reach a 95% P_{NP} with the armor panel testing, and to evaluate the BHT for ballistic shock, repairability, and structural strength against representative and overmatching threat systems. [Ref. 59:p. III-16] "The BHT will be used to help determine the most efficient and cost effective ways to fabricate the AAAV hull in order to achieve the required ballistic protection." [Ref. 59:p. III-16] The TEMP estimates 436 threat rounds being fired against 311 test panels. Shot lines analysis and actual shot data would be used to enhance already existing live-fire models. [Ref. 59:p. III-16]

With respect to operational test and evaluation, the 1995 TEMP no longer addresses OT-I. Instead, the TEMP identifies four EOAs to be conducted by MCOTEA. The DOT&E and DTSE&E's TEMP approval letter even directs the DRPM to complete the four EOAs in time to support the Milestone II decision. [Ref. 80] EOA-1 would assess an AAAV(C) non-operational mock-up for human factor issues while focusing on the a single Critical Operational Issue (COI); Can the AAAV(C) transport the Marine infantry regimental or battalion commander and required staff? [Ref. 59:p. IV-5] EOA-2 would assess a stationary operational mock-up of the AAAV(C) through the conduct of a Command Post Exercise (CPX) by an infantry battalion commander and staff. The intent of EOA-2 would be to evaluate the communication equipment's operational effectiveness (cooperative systems) and suitability (logistics support, software, and reliability), and the embarked personnel's suitability for training, human factors, staff position selection, and safety. [Ref. 59:p. IV-5]

EOA-3 would be an extensive one to three month assessment of the AAAV(P) pre-production prototype using amphibious and mechanized operational scenarios. These scenarios would be derived from the established Operational Mission Scenarios/Mission Profiles (OMS/MP). The EOA would assess eleven COIs that focus on the transportation of a reinforced rifle squad from OTH amphibious shipping to shore, the transition from amphibious operations to offensive and defensive mechanized land operations, and live-fire and maneuver exercises on instrumented ranges. [Ref. 59:pp. IV-4 through IV-8]

EOA-4 would be an assessment of the ATR(C)'s ability to command and control a Marine Air-Ground Task Force (MAGTF) in a mechanized environment with supporting arms. Seven COIs would be evaluated with similar operational effectiveness and suitability questions as assessed in EOA-2. [Ref. 59:p. IV-8]

Both Acquisition Plan DRPM AAA 95-1 and DRPM 96-1 Revision 2 classify the program's schedule risk as "Low." Acquisition Plan DRPM AAA 95-1 allows for a 30-month prototype fabrication phase, a six-month combined shakeout/acceptance test period, an eight-month DT-I period, a one-month refurbishment period, and a three-month OT-I period. [Ref. 81:p. 10] Acquisition Plan DRPM AAA 96-1 allows for a 15-month prototype fabrication phase, a 12-month combined shakeout/acceptance test period, an eight-month DT-I period, a one-month refurbishment period, and a three-month OT-I period. [Ref. 56:p. 10] The two Acquisition Plans boast, "The amount of testing allotted is six-to-ten times longer than conducted in D&V during the X-M1 tank program." [Refs. 56&70:p. 10] Acquisition Plan DRPM AAA 96-1 also indicates that the eight-month DT-I period attempts to accommodate prevailing ocean weather patterns at AVTB, Camp Pendleton, California. [Ref. 56:p. 10]

The 1999 Draft TEMP identifies significant changes to the conduct of developmental testing and EOAs in the PDRR Phase. Because of the system's maturity exiting the CE Phase, DT-I's testing goal became, "to produce an extremely mature AAAV design" by testing three prototypes' land mobility, track robustness, bollard pull, planing thresholds, reverse speeds, at-sea maneuverability, ride quality in 3-foot seas, stopping distances, towing capabilities, and surf zone negotiation. [Ref. 57:p. III-1] DT-I test objectives to meet the extreme maturity goal include the following [Ref. 57:p. 5]:

- Determine the system's capabilities to demonstrate Milestone II exit criteria.
- Determine the system's potential to satisfy critical technical parameters.
- Detect any safety design deficiencies.
- Provide data to evaluate current software and design maturation and provide input to design initiatives supporting DT-II phase.

- Certify readiness for EOA.

The TEMP also states, "Testing will conform with the requirements of DT-I...for baseline testing, however the vehicles will be tested to the edge of the design envelope as defined by the ORD." [Ref. 57:p. III-8] As discussed in the Test Management section, DT-I will be conducted as an integrated effort between the contractor and the government. MCOTEA will also maximize integration of DT and EOA events to reduce and avoid duplication of efforts. See Appendix E for the Integrated Program Schedule listed in the 1999 Draft TEMP.

The PDRR Phase test schedule becomes increasingly complex with the addition of two more prototypes. The current plan is for the three AAAV(P) prototypes to undergo separate test events as they come on-line so that the total time spent in the PDRR Phase is reduced. Shakeout and test site locations to complete the schedule originally included Quantico and Ft. Story, Virginia; Pax River Naval Air Station (NAS) and Aberdeen Test Center (ATC), Maryland; Eglin Air Force Base, Florida; and AVTB, Camp Pendleton, California. [Ref. 57:p. III-6] The additional prototypes also allow for the conduct of a logistics demonstration in the PDRR Phase. The logistics demonstration will serve to identify maintainability deficiencies, verify that supportability requirements have been met, and allow Fleet Marine Force personnel to provide input for corrective actions in the next phase. [Ref. 57:p. III-9]

The conduct of previously planned EOAs changed in the 1999 TEMP based on the AAAV(C) stop-work action. EOA-2 and EOA-4 were cancelled, while EOA-1 was modified in location and scope, and renamed EOA AAAV(C). The objectives of the AAAV(C) non-operational mock-up EOA are now [Ref. 57:p. IV-10]:

- To evaluate Human Factors including the man-machine interface, collaborative planning capability and placement/layout of workstations.
- To evaluate the suitability of the workstation to support effective staff functioning.
- To evaluate the ability of the staff to operate the workstations in crowded conditions.
- Identify user-originated recommendations for improving the system design.
- Identify needed improvements in procedures, instrumentation, and resources for future Operational Tests.

EOA-3 remains, but becomes referred to as the AAAV(P) Pre-production Prototype EOA with the following objectives [Ref. 57:p. IV-5]:

- To estimate the AAAV(P)'s potential to be operationally effective and suitable.
- Provide an early assessment of force-level effectiveness based on demonstrated system performance.
- Provide AAAV system performance data in support of Modeling and Simulation efforts.
- Identify user-originated recommendations for improving the system design.
- Assess system adequacy relative to the Concept of Employment.
- Provide information on AAAV waterborne movement and command and control in support of Ship-To-Objective-Maneuver (STOM).
- Identify safety risks and assess mitigation procedures.

- Identify needed improvements in procedures, instrumentation, and resources for future Operational Tests

The AAAV(P) EOA will be conducted in three parts. First, the vehicle will be assessed for its ability to conduct amphibious operations while completing designated Operational Mission Profiles (OMPs) at Camp Pendleton, California. Second, the vehicle's Mk 44 Automatic Cannon and Mk 46 Weapon Station will be assessed for their ability to conduct live-fire and maneuver at both Camp Pendleton and the Marine Corps Air-Ground Combat Center (MCAGCC), 29 Palms, California. The third phase will assess the vehicle's ability to conduct unrestricted land mobility and mechanized operations in a desert and hot weather environment. [Ref. 57:pp. IV-5 though IV-7] The TEMP indicates that, "This preliminary assessment of AAAV(P) operational effectiveness and suitability will support the Milestone II decision…" [Ref. 57:p. IV-5]

The 1999 Draft TEMP significantly expands the level of detail and objectives for the Live-Fire Test and Evaluation (LFT&E) portion of Section IV. The PMO's LFT&E program is managed by a separate LFT&T IPT responsible for, "LFT&E planning, program, execution and management, assessment and reporting of program results." [Ref. 57:p. IV-17] The AAAV LFT&E strategy provides for the "comprehensive evaluation of AAAV vulnerability and lethality" with a stated goal of identifying "potential susceptibilities and vulnerabilities as early in the development cycle as possible so that the most survivable AAAV possible can be fielded." [Ref. 57:p. IV-17]

The LFT&E strategy follows a building block approach by proceeding from armor and component ballistic tests, to ballistic hull and turret (BH&T) testing, to full-up system level (FUSL) testing. The testing uses extensive modeling and simulation to augment testing and estimate expected vulnerability performances. [Ref. 57:p. IV-17] Specific PDRR Phase LFT&E includes component ballistic testing, armor ballistic characterization testing, controlled damage testing, and commencement of BH&T testing. [Ref. 57:p. II-8] See Appendix F for the Live-Fire Schedule listed in the 1999 Draft TEMP.

Lethality testing will include testing and experimentation to evaluate 30mm High Explosive (HE) ammunition for inclusion in the Joint Munition Effectiveness Manual (JMEM). The DRPM AAA, Navy, and Air Force will conduct these experiments and Arena tests to develop a performance specification for joint requirements in order to field a common DoD family of 30mm ammunition. [Ref. 57:p. IV-18]

Other PDRR Phase testing events addressed in the 1999 Draft TEMP include [Ref. 57]:

- Lethality trade-off studies resulting in the selection of the 30mm Mk 46 Weapon Station.
- Foreign Competitive Testing (FCT) by Germany, the United Kingdom, and Norway for vehicle components and 30mm ammunition.
- Modeling and simulations to evaluate two Reliability, Availability, and Maintainability (RAM) critical technical parameters (CTPs) that lack sufficient data input from DT-I (Mean Time Between Critical Mission Failure (MTBCMF) and Operational Availability (A_o)).

4. Engineering and Manufacturing Development Phase

The test and evaluation strategy in the EMD Phase has been shaped by both the funding changes and the AAAV(C) requirements change. As with the PDRR Phase, the planned conduct of the test and evaluation strategy has evolved while the strategy's objectives remain relatively stable.

Funding level changes led to the program adopting an accelerated schedule causing the EMD dates to shift forward by almost two years. The 1995 TEMP's integrated test program schedule shows EMD starting in the second quarter of FY02 and ending at the close of FY07. [Ref. 59:p. II-2] The 1999 Draft TEMP's integrated program schedule shows the EMD phase beginning in the first quarter of FY01 and ending in the third quarter of FY05. [Ref. 57:p. II-8]

The program's EMD test and evaluation strategy begins with the 1988 Draft TEMP identifying a second Developmental Test event occurring in the EMD Phase. The DT-II event would occur in two parts. The first part would use refurbished PDRR prototypes, while the second part would test newer more mature prototypes and Mission Role Variants. [Ref. 58:p. 17] The purpose of DT-II is described as [Ref. 58:p. 17]:

- Demonstrating that engineering is reasonably complete.
- Ensuring all significant design problems that affect compatibility, reliability, maintainability, and logistic considerations have been identified, and that solutions are developed and economically feasible.
- Demonstrating R&M performance characteristics, terrain trafficability, environmental compatibility, and Integrated Logistic Support (ILS) requirements.

- Demonstrating that technical risks have been minimized.

- Evaluating training programs.

Acquisition Plan NAVSEA 88-043 indicates that the single contractor for this phase will develop prototypes for both developmental and operational testing to prove that, "the design and the related support equipment, facilities and software meet all required specifications." [Ref. 40:p. 5] The Acquisition Plan does not designate the number of prototypes to be built in EMD and in fact states, "...development and testing of a number of AAAV prototype vehicles limited to the quantity necessary..." [Ref. 40:p. 8] Acquisition Plan DRPM-AAA 90-002 refers to vehicle quantities as, "...up to 25 FSD [Full Scale Development] prototype AAAVs." [Ref. 79:p. 5]

The 1995 TEMP specifies that ten production representative AAAV(P) prototypes and one production representative AAAV(C) prototype be manufactured in the EMD phase. The eleven prototypes are to undergo DT-II testing for approximately twenty-three months while accumulating between 20 and 50 hours of operations per month. DT-II would be conducted by the government, at government facilities, and supported by the contractor. [Ref. 59:p. III-11] Additionally, eleven prototypes would allow for individual vehicle testing at separate locations, and would allow for combined vehicle operations at the assault amphibian platoon and section level. [Ref. 59:p. III-11]

The 1995 TEMP states that:

> DT-II testing is designed to demonstrate that engineering is reasonably complete, that technical risks have been minimized, that critical characteristics have been achieved (if not achieved, then technical solutions have been identified), to support a Low Rate Initial Production

> and Full Rate Production decision. Critical objectives to meet during testing will again include mobility (land and water), lethality, and survivability requirements. [Ref. 59:p. III-10]

Tests designated to occur in DT-II would involve speed, range, navigation, communication, ride quality, human factors and safety, amphibious ship compatibility, transportability, target acquisition, weapon lethality, and mobility. Very specific testing would include surf testing, cold environment testing, nuclear and NBC effects testing, hot weather/tropics testing, EMI testing, RAM-D testing, and ILS requirements evaluations. [Ref. 59:p. III-10]

Acquisition Plan DRPM-AAA 95-1 indicates that DT-II and Initial Operational Test and Evaluation (IOT&E) are planned for the EMD Phase using LRIP vehicles. [Ref. 81:p. 17] Acquisition Plan DRPM-AAA 96-1 Revision 2 states that DT-II and IOT&E are still planned for EMD, but the events would use "production representative vehicles" vice LRIP vehicles. [Ref. 56:p. 17]

The 1999 Draft TEMP describes extensive changes to the test concept for the AAAV(C) variant. At the completion of AAAV(P) DT-I, one prototype will be converted into an AAAV(C) in Fiscal Year (FY) 01, and then begin a separate development test plan track. The objectives of the AAAV(C) DT-I include determining the system's potential to satisfy Critical Technical Parameters (CTPs), determining human factor issues, identifying levels of design risk, and ensuring that the system's technical maturity is sufficient to support OT certification prior to Operational Assessment (OA) I. The focus will be on system, sub-system and inter-operability testing. [Ref. 57:p. III-11] DT-II for the AAAV(C) will be off-set from AAAV (P) DT-II, but will meet the same objectives.

The 1999 Draft TEMP maintains the use of ten AAAV(P) variants and one AAAV(C) variant for DT-II, maintains the type of tests to be conducted during DT-II, and maintains the twenty-three month DT-II duration. The objectives of DT-II are listed as [Ref. 57:p. III-12]:

- Assess AAAV RAM.
- Assess the vehicle's ability to meet all technical and operational performance requirements.
- Demonstrate resolution of design deficiencies noted in earlier testing.
- Demonstrate readiness for production.
- Demonstrate maturity of design and to assess vehicle's readiness for operational testing.
- Verify that technical risks have been minimized, and that critical characteristics have been achieved (if not achieved, then technical solutions have been identified).
- Support Low Rate Initial Production (LRIP) and Full Rate Production (FRP) decisions.
- Include interoperability between P and C variants and the battlefield.
- Assess ability to maneuver with other mechanized forces.
- Successfully integrate as part of the assault force in OMFTS.
- Demonstrate lethality, and survivability requirements.

During DT-II, a second Logistics Demonstration is scheduled to demonstrate improvements made from the lessons learned in the DT-I Logistics Demonstration. The Logistics Demonstration is scheduled to occur prior to FUSL and IOT&E. DT-II will also include extensive Reliability, Availability, and Maintainability – Durability (RAM-D) operations and data collection. [Ref. 57:p. III-11]

Operational testing for the EMD Phase is first described in the 1988 Draft TEMP as serving to, "...provide data and associated analysis on the operational effectiveness and suitability of the AAAV prior to Marine Corps Systems Acquisition Review Council (MSARC) III." [Ref. 58:p. 23] Acquisition Plan NAVSEA 88-043 and Acquisition Plan DRPM-AAA 90-002 give a similar account, but would use the OT-II results for the Milestone-III decision. [Refs. 40, 79]

The 1995 TEMP lists the Initial Operational Test and Evaluation (IOT&E) as the only operational test to occur in the EMD Phase. IOT&E would be a three part test using ten to twelve AAAV(P) vehicles and one AAAV(C) vehicle to demonstrate, "the ability to achieve all required operational thresholds." [Ref. 59:p. IV-9] These vehicles would be a combination of four LRIP vehicles and nine EMD production representative vehicles that were refurbished or remanufactured to production configuration, and therefore, IOT&E could be used to support the Milestone III decision and the decision to proceed into full rate production. [Ref. 59:p. IV-9]

Part One of IOT&E would be a combined DT/OT test of the AAAV's functionality and mobility in both tropical and arctic environments. Part Two would be conducted at Camp Pendleton, and would feature progressive OTH amphibious operations that built to a force-on-force full mission profile with all elements of a MAGTF. Part Three of the IOT&E would be conducted at 29 Palms, California and would feature force-on-force mechanized offensive and defensive operations. [Ref. 59:pp. IV-10 through IV-13]

When the 1995 TEMP was originally submitted to DOT&E in 1994, the TEMP was returned because of a Milestone date shift. The cover letter from DOT&E and DTSE&E on the returned TEMP addressed MCOTEA's force on force evaluation plan in the TEMP by stating:

> The methodology for the conduct and evaluation of Initial Operational Test and Evaluation remains unresolved. Prior to Milestone II, the Marine Corps must develop a scoring system that provides an effective method of measuring force on force evaluations with real time casualty assessment and vehicle removable from the battlefield. [Ref. 82]

With respect to LFT&E, the 1995 TEMP indicates that two AAAV(P) production representative vehicles would undergo twelve months of LFT&E at the Aberdeen Proving Grounds (APG) based on APG's extensive live fire testing experience. The DRPM believes that because the AAAV(C) variant shares the same hull configuration, additional LFT&E for the AAAV(C) would be unnecessary. [Ref. 59:p. III-17]

As with DT, the 1999 Draft TEMP makes significant changes to the OT plan. MCOTEA adds one Operational Assessment (OA-1) for the AAAV(C) variant in the second quarter of FY02, another Operational Assessment (OA-2) in the first half of FY04 for both the AAAV(C) and the AAAV(P) variant, and a third Operational Assessment (OA-3) in the third quarter of FY04. [Ref. 57:p. II-8] These OAs are in addition to the already scheduled IOT&E, which now is to occur in FY05.

Operational Assessment-1 will serve to assess the AAAV(C) variant's capabilities to operate in an amphibious and mechanized environment while battalion / regimental commanders and staff attempt to command and control their infantry units and supporting arms. The TEMP specifically states, "The OA will focus on assessing the unique characteristics of the AAAV Command Variant, primarily the ability of the battalion or regimental commander to command, control, and communicate with senior, subordinate, and adjacent units, and control supporting fires during OMFTS/STOM operations." [Ref. 57:p. IV-11] The OA will compare the capabilities of the AAAV(C) with the capabilities of the AAVC7A1 while focusing on the AAAV(C)'s following characteristics [Ref. 57:p. IV-11]:

- Ability of the Commander's staff to effectively operate the workstations.
- Suitability of workstation configuration to support effective staff functioning, including collaborative planning capability.
- Effectiveness of different operational environments on command and control capabilities.

The amphibious assessment will occur at Camp Pendleton in order to conduct OTH ship-to-shore movements while the mechanized assessment will occur in 29 Palms, California in order to conduct larger scale MAGTF operations.

MCOTEA identifies limitations to the OA as not satisfying all performance characteristics of the objective system because the vehicle will not be production representative. The vehicle for the OA will be the same converted AAAV(P) used in

AAAV(C) DT-I. "Consequently, any conclusions drawn from this OA will be preliminary and will be subject to verification during testing of the EMD command variant during OA-3 and IOT&E." [Ref. 57:p. IV-13]

OA-2 will involve the assessment of three AAAV(P) production representative vehicles in a subarctic cold weather environment. Testing will include combined DT/OT special events and OT events designed to assess vehicle design improvements since AAAV(P) PDRR prototype testing. [Ref. 57:p. IV-13] OA-2 has the following specific objectives [Ref. 57:p. IV-14]:

- Assess the effect of below freezing air temperatures during AAAV high water speed and transition mode operations, specifically icing effects as a result of salt spray and the effects on mechanical operation of above / below waterline moving parts, intakes, and exhausts; and effects on waterborne visibility.

- Assess the effects of subarctic conditions on AAAV land mobility and maneuverability, visibility, and gunnery.

- Assess the ability of the AAAV Environmental Control System to cope with subarctic conditions, and maintain operational effectiveness of crew and embarked Marines.

- Assess the effect of subarctic conditions on AAAV signature.

- Assess the ability of other AAAV systems and subsystems, displays, and computer hardware and software to cope with subarctic conditions.

- Assess the human factors interface associated with cold weather operations and AAAV operation, controls and displays.

- Initial assessment of AAAV section tactics, techniques, and procedures.

- Assess operational and troubleshooting procedures using on-board technical manuals and built-in test equipment.

- Assess logistical and maintenance support concepts and procedures.

Afloat tests are to occur in Valdez, Alaska and will include day, night, and twilight water operations at high and low water speeds. Ashore tests are to occur at Ft. Greeley, Alaska and will include day and night land mobility and gunnery operations. MCOTEA estimates requiring a minimum of 100 hours of land operations and 25 hours of water operations for meeting OA-2 objectives. [Ref. 57:p. IV-14]

OA-3 involves the assessment of one AAAV(C) and five AAAV(P) production representative vehicles in a subtropical environment. The vehicles are to possess, "all of the production design capabilities and like hardware for form, fit, and function." [Ref. 57:p. IV-16] Testing for OA-3 will also include some combine DT/OT special test events for gunnery, signature, and the high humidity environment. Specific test objectives for OA-3 include [Ref. 57:p. IV-17]:

- Make final system performance assessment of both AAAV variants.
- Preliminary assessments of AAAV unit contribution to armored/mechanized landing forces.
- Rehearse test events and conditions for IOT&E.
- Continued assessment of AAAV section tactics, techniques, and procedures.
- Continued assessment of operational and troubleshooting procedures using on-board technical manuals and built-in test equipment.
- Assess logistical and maintenance support concepts and procedures.
- Assess the effects of subtropical conditions on AAAV water and land mobility and maneuverability, visibility, and gunnery.

- Assess the ability of the AAAV Environmental Control System to cope with subtropical conditions, and maintain operational effectiveness of crew and embarked Marines.

- Assess AAAV signature under representative operational conditions.

- Assess the ability of other AAAV systems and subsystems, displays, and computer hardware and software to cope with subtropical conditions.

- Assess the human factors interface associated with high heat and humidity operations and AAAV operation, controls and displays.

- Assess the suitability of the AAAV(C) staff workstation configuration to support effective staff functioning and collaborative planning.

- Assess the placement of workstations and working environment in the AAAV(C).

- Assess the ability of the commander to communicate with senior, subordinate, and adjacent units and control supporting fires via the AAAV(C).

OA-3 is to be conducted in three phases. Phase One will involve day and night OTH amphibious operations at Camp Pendleton with an assault amphibian section operating against representative threat forces ashore and afloat. Phase Two is a training phase in preparation for the next phase. Phase Three is the subtropical environment assessment scheduled to occur at Eglin Air Force Base, Florida. Phase Three involves shore-to-shore operations designed to represent OTH movements, and ashore operations having, "inland objectives 50-100 NM [Nautical Miles] inland, or as can be simulated at Eglin AFB." [Ref. 57:p. IV-18] The force-on-force events will be designed to provide insight into data collection for IOT&E and for Force-on-Force Real Time Casualty

Assessment (FOF RTCA). MCOTEA estimates accumulating a minimum of 500 hours of land operations and 100 hours of water operations. [Ref. 57:p. IV-19]

The 1999 Draft TEMP increases in detail its description of IOT&E. Specific changes from the 1995 TEMP include number and type of test articles, number and scope of phases, and enhancements to FOF RTCA.

The number of test articles for IOT&E has decreased from the originally planned 10-12 vehicles to eight AAAV(P)s and one AAAV(C). These vehicles will equate to one AAAV platoon (-) and an AAAV(C) command element. An AAAV platoon(-) represents the number of AAAVs used in a mechanized infantry company with a cross attached tank platoon. [Ref. 57:p. IV-20] This mechanized team, or "Team Mech," is representative of existing doctrinal tactics. The IOT&E test articles are to be, "production representative EMD prototypes that contain both the objective hardware and software components of the production versions." [Ref. 57:p. IV-20]

The TEMP states the following IOT&E objectives:

> The IOT&E results will support the MS-III full rate production decision. The IOT&E will evaluate the operational effectiveness and suitability of the AAAV during the amphibious assault; AAAV(P)s in support of platoon and company mechanized maneuver elements; and the AAAV(C) as a tactical echelon headquarters for an infantry battalion or regiment. Logistical and maintenance support concepts will be fully tested, and RAM data will be collected throughout the IOT&E. The IOT&E will obtain estimates for the AoA's [Analysis of Alternatives] MOEs [Measures of Effectiveness] with the Force on Force (FOF) Real Time Casualty Assessment (RTCA), and provide data to resolve all AAAV COIs... [Ref. 57:p. IV-20]

To meet these objectives, MCOTEA plans to conduct IOT&E over five phases. Phase One involves Pre-IOT&E operator and maintainer training given by Assault Amphibian School personnel at Camp Pendleton. Phase Two will be Amphibious Operations testing at Camp Pendleton. The Amphibious Operations phase is designed to, "evaluate the operational effectiveness and suitability of the AAAV and AAAV units during Over-The-Horizon amphibious operations, and to resolve the Force Build-up and Movement MOEs [Measures of Effectiveness] associated with the ship-to-shore phase of landing operations." [Ref. 57:p. IV-21] The amphibious phase is also designed to evaluate the AAAV crews' and units' ability to maintain situational awareness and integrity during the OTH movement to shore in all conditions while integrating with LCACs and supporting arms. [Ref. 57:p. IV-21]

Phase Three involves gunnery operations at 29 Palms, California on an instrumented live fire range. Gunnery operations are to be conducted under a wide variety of different conditions based on established AoA scenarios. The phase will also evaluate newly established gunnery tables designed for the Mk 46 Weapon Station. [Ref. 57:p. IV-22]

Phase Four of IOT&E evaluates the ability of the AAAV unit to participate in well-established Combined Arms Exercises (CAX) at 29 Palms, California. Combined Arms Exercises focus on a regimental headquarters' ability to command and control a battalion that is conducting live-fire and maneuver, offensive and defensive operations with all supporting arms available to the MAGTF. The AAAV(P) will be evaluated for its ability to operate in a training exercise in support of a mechanized company task force. The AAAV(C) will be tested and evaluated for its ability to, "perform as a tactical echelon headquarters, provide needed connectivity to senior, subordinate, and adjacent units, and to coordinate the use and movement of designated supporting arms." [Ref. 57:p. IV-23]

The fifth phase of IOT&E addresses the concerns expressed by DOT&E and DTSE&E in their comments about the 1994 TEMP submission. Force-on-Force (FOF) field testing with Real Time Casualty Assessment (RTCA) is to be conducted for a 30-day period immediately following the CAX. An AAAV equipped force will be compared to an AAV7A1 equipped force for combat effectiveness. Specifically, "MCOTEA will use the most current FOF RTCA system available at the time to provide a method of measuring FOF evolutions with RTCA and vehicle removal from the battlefield. Four of the five AoA MOEs can be resolved via FOF field testing with RTCA." [Ref. 57:p. IV-23]

Scenarios for the FOF RTCA will be developed through the use of AoA modeling and simulation, and through an analysis of the Operational Mission Summary/Mission Profile (OMS/MP) for AAAV capabilities that are to significantly enhance the supported units. [Ref. 57:p. IV-23] Scenario scoring of the four evaluated MOEs is to be conducted by the U. S. Army Test and Experimentation Command, and is listed as [Ref. 57:p. IV-23]:

- Loss-Exchange Ratio. Comparison of remaining combat power of AAAV equipped blue force versus remaining combat power of red force after each scripted mission and remaining combat power of AAV equipped blue force versus remaining combat power of red force after each scripted mission.

- Force Movement. Force movement will be scored indirectly. The amount of time an AAAV equipped blue force takes to accomplish each scripted mission versus amount of time an AAV equipped blue force takes to accomplish each scripted mission. This indirect method of resolving this issue is required due to the limited amount of terrain that can be instrumented.

- Fraction of Force Surviving. The fraction of AAAV equipped blue forces surviving and red forces surviving after each scripted mission compared to fraction of AAV equipped blue force surviving and red force surviving after each scripted mission.

- Force Ratio. The ratio of AAAV equipped blue forces and red forces surviving after each scripted mission compared to the ratio of AAV equipped blue forces and red forces surviving after each scripted mission.

The 1999 Draft TEMP also increases it descriptive detail concerning LFT&E, with emphasis added to the level of testing. The 1995 TEMP's integrated Test Program Schedule indicates that only full-up system level testing would occur in the EMD Phase. The 1999 Draft TEMP amplifies the DRPM's LFT&E strategy building block approach by continuing testing throughout EMD. Ballistic hull and turret (BH&T) testing is to continue into the EMD phase, and then armor and component ballistic testing and controlled damage testing would continue until full-up system level (FUSL) testing. [Ref. 57:p. II-8] The testing would continue use of extensive modeling and simulation to augment testing and estimate expected vulnerability performances. [Ref. 57:p. IV-17]

5. Production, Fielding / Deployment, Operations, and Sustainment Phase

The DRPM's test and evaluation strategy for the PF/DOS Phase is not fully established at this time. The references to production testing, FOT&E, and First Article Testing appear to be merely place holders in all versions of the TEMP until future attention can be applied to their development.

The 1988 Draft TEMP discusses a third DT event (DT-III) that is, "designed to demonstrate that production is in accordance with the protection data package and that the technical and engineering requirements have been satisfied including correction of previously identified discrepancies." [Ref. 58:p. 18] DT-III was to be conducted by AVTB with detailed test plans being generated by the government. A third OT event (OT-III) would test production vehicles in a realistic platoon environment with the first FMF unit equipped with the AAAV. OT-III would validate the correction of previously identified deficiencies. [Ref. 58:p. 24]

The 1988 Draft TEMP does dedicate a full page to Production Acceptance Test and Evaluation (PAT&E). It identifies the purpose of the acceptance tests as ensuring the production items meet the requirements and specifications of the contract. [Ref. 58:p. 25] Initial production tests would randomly select vehicles in the first three months of production and subject them to 600 hours of durability testing. Additionally, 100-hour control and comparison testing would occur on production vehicles at randomly selected times. [Ref. 58:p. 25]

The 1995 TEMP states that, "Detailed LRIP and Production test events, scope, and scenario have not been developed for the AAAV at this time." [Ref. 59:p. III-12] However, the TEMP does identify First Article Testing (FAT) for two LRIP and two production vehicles in order to demonstrate that design specifications are met, and that manufacturing processes are acceptable. [Ref. 59:p. III-12] The TEMP also identifies possible testing of another ballistic hull and turret to ensure production techniques meet vulnerability requirements. [Ref. 59:p. III-18] Part Four of the TEMP addresses Follow-on Operational Test and Evaluation (FOT&E) as follows:

> The AAAV may undergo FOT&E during Production and Deployment to evaluate major system modifications of product improvements, along with tactical employment within the MAGTF. FOT&E Test events, scope of testing, and scenarios will depend on IOT&E results and modifications made after IOT&E, but applied before full rate production. FOT&E will provide operational environments for evaluating systems against any operational deficiencies or shortcomings found during IOT&E. [Ref. 59:p. IV-15]

The 1999 Draft TEMP is as vague about production testing as the 1995 TEMP. Verbiage in Part Three of the 1999 Draft TEMP mirrors its predecessor with the exception that only two LRIP and no production vehicles would be used for FAT. [Ref. 57:pp. III-14, III-15] The 1999 Draft TEMP's Part Four references to FOT&E are verbatim to that listed above for the 1995 TEMP. [Ref. 57:p. IV-26]

E. REQUIREMENTS DEVELOPMENT AND RECONCILIATION PROCESS

The goal of the Program Manager is to field a system that meets the needs and requirements of the user. Thus, the development and evolution of requirements serve as a reference point from which the program's test and evaluation strategy is based. Reconciliation of system requirements throughout the system's development ensures that the final product can actually perform as desired.

1. Initial Requirements

Prior to entering the Milestone 0 process, the AAAV program office focused on meeting the fundamental technical requirements for developing a high water speed assault amphibian vehicle. The 1988 Draft TEMP lists the following Required Technical Characteristics deemed necessary for the AAAV [Ref. 58:p. 7]:

- Tracked Vehicle.
- Must carry a reinforced Squad (17-18 Marines).
- M1A1 Tank / Future Main Battle Tank (MBT) mobility.
- 14.5 millimeter (mm) hull protection without applique armor.
- Weapon system to defeat Soviet BMP (armored personnel carrier) threat.
- Support dismounted infantry.
- Night / All weather capability.
- Accurate fire while moving on both land and water.
- High water speed of 20-25 knots in Sea State Three (SS-3).
- Slow water speed of at least 10-12 knots.
- Survive in Sea State Five (SS-5).
- Negotiate 8-10 Foot plunging surf.

- Self-navigation at sea.
- Maximum crew of three (Driver, Commander/Gunner, Assistant Driver).
- Maximum commonality with other systems (U. S. Army Armored Family of Vehicles).

The technical annex to Acquisition Plan NAVSEA 88-043 Revision 1 (89) identifies very similar characteristics as constraints to the AAAV's acquisition. The acquisition plan states in broad terms that, "The AAAV must be compatible with approved U.S. Marine Corps and U.S. Navy amphibious doctrine, tactics, and equipment." [Ref. 40:p. 9] In more specific terms, the acquisition plan adds that the AAAV must be capable of high water speeds greater than 20 miles per hour, and that it will be a fully amphibious armored personnel carrier possessing a weapon system sufficient to [Ref. 40:p. 9]:

- Provide effective direct offensive and defensive fire support for mounted and dismounted infantry.
- Provide sufficient firepower to destroy the threat BMP of the timeframe.

Acquisition Plan DRPM-AAA 90-002 makes only slight changes to the technical constraints listed in NAVSEA 88-043. The 1990 acquisition plan specifies that the AAAV achieve high water speeds of grater than 20 knots vice miles per hour, and that the AAAV be capable of transporting a reinforced rifle squad and "associated equipment". [Ref. 79:p. 10]

2. Cost and Operational Effectiveness Analysis (COEA)

During the Milestone 0 decision process, the PMO was directed to, "examine all alternatives of placing infantry ashore, not just a new amphibious vehicle." [Ref. 60:p. 1] Based on this guidance, the PMO expanded the Cost and Operational Effectiveness Analysis (COEA) from three systems to thirteen possible systems. The thirteen systems fell into four general categories. The first category of "high-speed amphibians" contained the AAAV(Fast) which would be a newly designed system, and the AAV7A2 which would be an improved AAV7A1 capable of achieving high-water speed. [Ref. 60:p. 1]

The second category was designated "low-speed amphibians" and contained four possible systems. The existing AAV7A1 would serve as a baseline system. The AAV7A2(Slow) would contain product improvements to the existing system, but would not attain high water speed. The AAAV(Slow) would be a newly designed vehicle capable of only low water speeds. The fourth low-speed candidate was a fully submersible tracked vehicle that would transit to the shore below the water's surface. [Ref. 60:p. 1]

The third category of possible systems was designated "non-amphibian" and contained five possible systems. Receiving consideration was the Armored Personnel Carrier (Experimental) (APC(X)) which would be a newly designed APC. Other "non-amphibians" receiving consideration were the USMC's current LAV-25 wheeled vehicle, the U.S. Army's M2A2 Bradley Fighting Vehicle, the U.S. Army's M113A3 APC, and the U.S. Army's Future Infantry Fighting Vehicle (FIFV). [Ref. 60:p. 1]

The final category of possible systems was designated "non-vehicle" and contained only two options. The surface option examined bringing infantry ashore in shelters mounted on LCACs. The air option was to simply bring all infantry ashore with an existing helicopter system. For the COEA, the U.S. Army's CH-60 was used as the representative aircraft. [Ref. 60:p. 5]

The original COEA began by analyzing the possible systems in the areas of system performance, force effectiveness, and life-cycle cost. Six systems were eliminated based on performance while the remaining systems were analyzed for their contribution to force capabilities. The systems were compared in force-on-force scenarios using established force-level Measures of Effectiveness (MOEs) resulting in three more systems being screened out. [Ref. 60:p. 11] The remaining systems were then compared for life-cycle costs. As a result, the AAAV(Fast), or AAAV, was determined to best meet the needs of the Marine Corps. [Ref. 60:p. 11]

In 1993, the COEA was updated for the next milestone review. That COEA examined four new alternatives, which examined different combinations of high-speed and low-speed vehicle employment. Again, the AAAV was determined to be the best system for the Marine Corps with the following justification:

> The AAAV(F) is the most promising and operationally effective evaluated. Its inherent characteristics provide an amphibious force with the ability to use speed as a weapon; through the rapid concentration of its available combat power at a decisive place and time. All other alternatives...inhibit our ability to seize the initiative and dictate the terms of combat by forcing the enemy to react to us. Without this initiative an amphibious force's survivability and security is greatly diminished, along

with the loss of essential elements that enable maneuver and surprise. [Ref. 60:p. 14]

The DRPM further justified the selection of the AAAV at the 1994 Acquisition Review Board by stating, "Alternatives other than the AAAV(F) tend to move the amphibious force in a direction of an attrition style warfare instead of in the direction of maneuver warfare, which is the doctrinal foundation for all U. S. Marine Corps operations." [Ref. 67]

An extract from the Integrated Program Summary is provided in Appendix G. The extract covers an extensive review of the thirteen candidate systems, and the justification for selection or non-selection of each system or mix of systems. Additionally, Appendix H provides a description of the selected AAAV system as it appears in the 1999 Draft TEMP.

3. Key Performance Parameters

Based on the results of the initial COEA of 1991, the DRPM sought approval from the Joint Requirements Oversight Council (JROC) for the objective and threshold values of the required capabilities shown in Table 4 [Ref. 83]:

Performance	Objective / Threshold
High Water Speed (Sea State-Three)	25 knots / 20 knots
Transition Mode	8.6 knots / 7 knots
Surf Capability	10 feet / 8 feet
Cross Country Speed	30 mph / 30 mph
Armor Protection	30mm@ 1000m / 14.5mm@ 300m Frontal 60° Arc / any azimuth
Firepower	BMP-3(+30mm) / BMP-3(+13mm)
Troop Capacity	18 / 18
Mean Time Between Critical Mission Failure (MTBCMF)	58 hrs / 39 hrs

Table 4. 1991 AAAV Required Capabilities. [Ref. 83]

The establishment of these values was justified to the JROC in terms of operational significance. Threshold high water speed was the minimum necessary to stay within acceptable ride quality criteria established by Fatigue Decreased Proficiency Mil-Std-1472B. Objective speed was established to provide a margin accommodating range and sea state error, and additional hydrography standoff while still maintaining Mil-Std criteria. [Ref: 83]

Transition mode threshold speed was the minimum speed necessary for safe transit of the surf zone to prevent broaching of the vehicle. Objective transition mode speed provided a safety margin for surf zone transit. Surf capability threshold and objective heights were based on a performance band beyond which joint operations with landing craft became no longer practical. Cross country speed threshold and objective values provide sufficient capability to permit employment in battlefield formations with the Main Battle Tank of the time frame. [Ref: 83]

Armor protection threshold values are based on the most likely or most abundant threat light armored vehicle gun caliber, while objective values are based on providing protection against the remaining threat light armor vehicles expected to be encountered and engaged. Firepower threshold values are based on estimated armor levels plus the minimum established behind-armor effects encountered at minimum required engagement ranges. The objective values are based on penetration capabilities plus the behind-armor effects at desired engagement ranges. [Ref: 83]

Troop carrying capability threshold and objective values are based on retaining the integrity of the smallest tactical unit (reinforced rifle squad) that prevents increases in manpower requirements, and that retains doctrinal lift requirements within shipping constraints. Reliability threshold and objective values would provide an 88% and 92% respective probability of successfully completing the primary mission. [Ref: 83]

In response to the DRPM's request, the JROC made three specific recommendations to the Marine Corps. First, "That the high-water-speed performance objective be stated in terms of speed over a given time, i.e. endurance." Second, that the Mean Time Between Critical Mission Failure (MTBCMF) performance objective "be stated as a range, vice a specific number." Third, that the performance objectives convey the requirement for "continuous mobility of Marine forces." [Ref. 84] In the Draft Memorandum for the Under Secretary of Defense for Acquisition, the Vice Chairman of the Joint Chiefs of Staff concludes that:

> ...the following are key thresholds/goals for the acquisition program baseline: (a) attain a water speed of 20-25 knots in sea state three for not

less than one hour duration; (b) provide continuous overland mobility at a speed which will permit tactical employment with the main battle tank in use during the AAAV's projected service life; (c) provide improved armor protection over the existing system; (d) provide the carrying capacity for a reinforced Marine Rifle Squad (eighteen combat equipped Marines); (e) possess sufficient firepower to defeat threat light armored vehicles; (f) be sufficiently reliable to accomplish the critical elements of the mission profile and still achieve a unit C-1 readiness status. [Ref. 84:Tab 1]

Table 5 identifies the Key Performance Parameters (KPPs) as revalidated by the JROC on 16 February 1995, and reported in DRPM AAA Selected Acquisition Reports.

Performance Characteristics	Objective / Threshold
High Water Speed (SS-3, 36 inch Significant Wave Height)	25 knots / 20 knots
Forward Speed on a Hard Surface Road	72 kph / 69 kph
Armor Protection Against	30mm@1000m / 14.5mm@300m
Carry Capacity (Marines)	18 / 17
Firepower (Maximum Effective Range)	2000 meters / 1500 meters
Reliability - Mean Time Between Critical Mission Failure (MTBCMF)	95 hrs / 70 hrs

Table 5. 1995 JROC Approved Key Performance Parameters for AAAV. [Ref. 71]

Based on the Key Performance Parameters, the following Milestone II exit criteria were developed and approved [Ref. 57:p. III-4]:

- Complete 1000 hour engine durability test.
- Demonstrate speed of 20 knots in Sea State 2 for 1 hour.
- Demonstrate 64 kph forward speed on a hard surface road.
- Validate armor performance:
  - 95% Probability, no penetration from 14.5mm @ 300m.
  - 99% Probability, no penetration from 155mm fragments airburst @50 feet above the top of the vehicle.

4. Critical Technical Parameters

Once the COEA confirmed the AAAV as the desired system, MCCDC developed and approved the Operational Requirements Document (ORD) in 1994. After outlining the AAV7A1's deficiencies, the ORD describes the AAAV's required capabilities in the context of Operational Maneuver From the Sea (OMFTS) / Over the Horizon (OTH) doctrine, and with respect to the anticipated threat capabilities of the future. [Ref. 2] In broad terms the ORD states, "The threat to naval amphibious forces in the 21st century will encompass the entire operational spectrum of military capabilities ranging from dissident / guerrilla forces to sophisticated first line equipped, regular forces." [Ref. 2:p. 8] The ORD's system performance overview specifically states that, "The AAAV must have the water mobility to support FTS [From the Sea] and OMFTS concepts of operations and be compatible with naval amphibious shipping of the 2005-2025 time frame...The AAAV will be subject to worldwide employment in all conflict environments." [Ref. 2:p. 12]

The ORD goes on to describe the detailed operational requirements that the AAAV must be capable of performing. The ORD, the Acquisition Program Baseline, and the 1995 TEMP all list the same six critical system characteristics. These six characteristics match the KPPs established by the JROC in 1995 (Table 5), and serve as a foundation for the AAAV program. [Ref. 59:p. I-6]

The system's Critical Technical Parameters (CTPs), listed in both the 1995 TEMP and the 1999 Draft TEMP, are a derivative of the extensive ORD requirements. The

1999 Draft TEMP lists the following major categories of CTPs, and number of CTPs per category [Ref. 57:p. I-14]:

- Survivability (7).
- Land Mobility (12).
- Water Mobility (8).
- Reliability, Availability, Maintainability (7).
- Interoperability (5).
- Logistics / Supportability / Human Factors (10).
- Firepower - AAAV(P) (4).
- AAAV(C) Unique (4).

Appendix I lists all AAAV Critical Technical Parameters as defined in the 1999 Draft TEMP.

5. Critical Operational Issues

In Part IV of the 1995 TEMP, MCOTEA describes their approach to the AAAV's evaluation as follows:

> The purpose of operational test and evaluation is to provide information to support decisions that consider the operational effectiveness and suitability of a system. This is regularly accomplished by resolving Critical Operational Issues (COIs) or questions that are considered operationally significant. Operational test and evaluation provides a basis for the resolution of COIs by comparing system characteristics to operational requirements in a realistic operating environment...[F]avorable resolution of every COI will result in the system being operationally effective and suitable. [Ref. 59:p. IV-1]

MCOTEA establishes and lists three COIs for evaluation of the AAAV's operational effectiveness, five COIs for the AAAV's operational suitability, three AAAV(P) unique COIs, and two AAAV(C) unique COIs. The COIs listed in the 1995 TEMP are as follows [Ref. 59:pp. IV-2,3]:

Operational Effectiveness COIs

- Does the AAAV support the Marine Corps' concept for Over-The-Horizon (OTH) amphibious assault and other amphibious operations worldwide?

- Is the AAAV capable of conducting sustained operations over varied terrain, at speeds permitting tactical employment with the Main Battle Tank (MBT) and other combat vehicles?

- Does the AAAV meet the Marine Corps' requirement for survivabilty?

Operational Suitability COIs

- Does the AAAV meet Marine Corps requirements for reliability, availability, and maintainability (RAM)?

- Is the AAAV transportable by means of land, sea, and air transport?

- Can the AAAV be operated and maintained in accordance with the Marine Corps' plans for personnel selection, training, organization, concept of employment and logistic support?

- Does the design of the AAAV provide for Marine-machine interface, and safe operations and maintenance?

- Is the AAAV's software usable and maintainable?

AAAV(P) Variant Unique COIs

- Will a reinforced combat-equipped Marine rifle squad be mission-effective after transportation over land and sea in a AAAV(P)?

- Is the AAAV(P) armament effective, including, lethality, against the lightly armored threat targets specified in the System Threat Analysis Report (STAR)?

- Does the AAAV(P) enable the embarked Marine rifle company or platoon commander to command and control subordinate units, communicate with higher and adjacent units, and coordinate supporting arms with supporting and supported units during amphibious assaults and operations ashore?

<u>AAAV(C) Variant Unique COIs</u>

- Can the AAAV(C) transport the Marine infantry regimental or battalion commander and required staff?

- Does the AAAV(C) enable the embarked regimental or battalion commander and staff to command and control subordinate units, communicate with higher, lower, and adjacent units, and coordinate supporting arms with supported and supporting units?

MCOTEA makes significant changes to the description of their evaluation approach and to the COIs listed in the 1999 Draft TEMP. A more detailed summary of MCOTEA's evaluation approach to OT&E includes, "Use of test scenarios that focus on AAAV resolution of Critical Operational Issues, and integration into future fighting concepts to aid in validation of AAAV tactics." [Ref. 57:p. IV-1] MCOTEA's description of critical operational issues is expanded as follows:

> The AAAV COIs are directly traceable to the performance of the AAAV mission in intended warfighting concepts such as Operational Maneuver From the Sea/Ship-To-Objective-Maneuver (OMFTS/STOM), and during Sustained Operations Ashore (SOA)...Satisfaction of the COIs over the course of the AAAV OT&E Program, and subsequent evaluation of system operational effectiveness and suitability will significantly reduce program risk and provide required information on system performance and force level effectiveness to senior decision-makers. [Ref. 57:p. IV-3]

The newly developed COIs are designed to, "capture the top level issues associated with AAAV system and mission level performance" and are as follows [Ref. 57:p. IV-3]:

Operational Effectiveness COIs

- Does an AAAV-equipped amphibious force support the Navy-Marine Corps Team's concept of an Over-The-Horizon (OTH) amphibious assault capability?
- Does an AAAV-equipped mechanized force significantly enhance the force's ability to fight and survive during combat operations ashore against future threat forces?

Operational Suitability COI

- Is an AAAV-equipped force reliable and supportable throughout anticipated wartime and peacetime operations?

Part IV of the 1999 Draft TEMP further states that these new COIs are directly linked to: the Mission Needs Statement; the Acquisition Program Baseline Key Performance Parameters and the Operational Requirements Document; and the Measures of Effectiveness discussed in the Analysis of Alternatives/COEA. [Ref. 57:p. IV-3]

6. Measures of Effectiveness and Measures of Performance

Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) for the AAAV were developed to support the initial COEA. The COEA analyzed the candidate systems from a system performance perspective. The MOPs developed to analyze performance include ship-to-shore movement, mobility ashore, survivability and lethality. [Ref. 60:p. 11] These performance measures were used to, "screen the least capable systems from the group in order to concentrate the bulk of analytical resources on the more promising alternatives." [Ref. 60:p. 11]

The COEA then used MOEs at the force level in order to compare the remaining systems in force-on-force scenarios. The force-on-force scenarios covered the full range of combat intensity levels and analyzed the different candidate systems' contribution to the force's overall capability to conduct amphibious operations. The MOEs developed for COEA effectiveness analysis include Loss Exchange Ratio (LER), force movement, percentage of force survival, force ratio, and time to move the assault element from ship to shore. [Ref. 60:p. 11] Table 6 is from the 1995 TEMP and shows the relationship between the AAAV MOEs and MOPs, and establishes the basis for testable criteria from the ORD requirements.

7. Specifications and Detailed Test Plans

General Dynamics has developed both the specification and the detailed test plan for DT-I with governmental input and approval. The specification for the AAAV(P) serves as the Functional Baseline for the AAAV Program and is titled, Advanced Amphibious Assault Vehicle Personnel Vehicle System/Subsystem Specification. [Ref. 85] The specification identifies the technical and mission requirements for the AAAV as an entire system, allocates requirements to functional areas, documents design constraints, and defines the interfaces between and/or among the functional areas. The document further states, "This specification is based upon the Operational Requirements

Document (ORD) and the technical / functional parameters developed during the Concept Exploration and Definition Phase of the program." [Ref. 85]

MOP	ORD Ref.	MOE				
		Loss-Exchange	Force Movement	% Force Surviving	Force Ratio	Movement Time
Ship to Shore Movement						
Water Speed	4.a.(2)(b)		X		X	X
Surf Transit	4.a.(2)(d)		X		X	X
Seaworthiness	4.a.(2)(f)		X	X	X	X
Land Mobility						
Cross Country Speed	4.a.(5)		X		X	X
Slope Climbing	4.a.(5)(f)		X		X	X
Varied Terrains	4.a.(5)(f)		X		X	X
Maximum Speed	4.a.(5)(a)		X		X	X
Survivability						
Prob. of Being Hit	4.c.(1)	X		X	X	
Armor Protection	4.c.(1)(b)	X		X	X	
Lethality						
Weapon Accuracy	4.a.(3)	X		X	X	
Armor Penetration	4.a.(3)	X		X	X	

Table 6. AAAV MOE and MOP testable criteria relationships. [Ref. 59:p. I-8]

The specification establishes the precedence of various requirements documentation as follows:

> In the event of conflict between the ORD and the contents of this specification, the contents of this specification shall be considered as the superseding requirement. Where differences between the ORD and the Mission Essential Functions/Characteristics (as stated in the Wartime Mission Profile/Operational Mode Summary and Peacetime Mission

Profile) exist, the contents of the ORD shall be considered as the superseding requirement. [Ref. 85]

The combine DRPM-AAA and GDAMS test plan for DT-I was established in 1 June 1999 as Contract Data Requirements List (CDRL) T005 under the AAAV Demonstration and Validation Contract of 13 June 1996. [Ref. 86] The test plan lists its objective as, "...to validate at the system/vehicle level all of the performance requirements for the Milestone II exit criteria; the Critical Technical Parameters as defined in the TEMP; and the test parameters of the AAAV System Validation Matrix contained in the System/Segment Specification." [Ref. 86] The test plan is actually divided into five subtest plans, or "Books," in order to facilitate use and transmittal. The books are Land Mobility, Water Mobility, Firepower, Specialty, and Electromagnetic Compatibility/Electromagnetic Interference (EMC/EMI). [Ref. 86]

The test plan identifies the test process as first focusing on vehicle operational safety and proper system functionality. The process would then be conducted in a spiral nature such that performance and functional tests are gradually increased in complexity and risk. [Ref. 86:p. 6] The objectives for land and water mobility testing include validation of the land and water mobility performance requirements listed in the AAAV System Validation Matrix of the System/Segment Specification. [Ref. 86] The Firepower testing objective is identified as, "...to provide confidence that the weapon station design meets the requirements defined in the SOW [Statement of Work] regarding performance and maintainability." [Ref. 86] The objectives for Signature testing are designed to collect data that allows "as-built signature performance" to be compared with thermal infrared, radar, acoustic, and magnetic signature performance requirements. [Ref. 86] Similar objectives, "... to verify that the AAAV meets all requirements specified in the AAAV system specification...," are listed for EMC and EMI testing. [Ref. 86]

8. Requirements Reconciliation

The purpose of requirements reconciliation is to ensure that the desired performance characteristics sought by the user match those characteristics achieved by the production system. The reconciliation of requirements generally occurs at three levels. First, the requirements listed in the ORD are reviewed and updated for each Milestone. MCCDC is currently reviewing and revising the AAAV ORD in preparation for Milestone II using an IPT process. The ORD IPT is chaired by the AAAV ORD Action Officer from MCCDC and contains members from MCOTEA, DRPM AAA, DOT&E, and other as required. [Ref. 87]

On 6 April 1999, the DRPM made a request to MCCDC for 48 clarifications to the ORD in preparation for the first EOA. The requested clarifications generally seek more detailed definitions or more specific performance criteria. [Ref. 88] The DRPM's request specifically states, "Extensive planning to execute the EOA is currently ongoing. A critical step in operational test planning is ensuring the relationship between the vehicle design and operational requirements are explicitly articulated for effective assessment of vehicle operational performance." [Ref. 88]

Based on the DRPM's original request, MCOTEA submitted an ORD clarification request that sought even greater detail from MCCDC. On 22 and 23 July 1999, MCOTEA held an ORD clarification meeting in order to assist in the reconciliation process. Attendees from MCCDC, DRPM AAA, and MCOTEA worked through MCOTEA's concerns and identified acceptable verbiage that would be included in the updated ORD. [Ref. 89] MCOTEA's concerns involved requirements that were difficult to measure in an operational environment, and terminology that was inconsistent through out the ORD and conflicted with what was contained in the specification. Of note, the representative from each of the attending agencies was an experienced officer from the Assault Amphibian Vehicle community. [Ref. 89]

The second level of requirements reconciliation occurs during the update of the TEMP. The TEMP ensures that specified ORD requirements are translated into Critical Technical Parameters, and that the established COIs can be met by the established MOEs and MOPs. The 1999 Draft TEMP's listing of CTPs references specific ORD paragraphs to ensure continuity. [Ref. 57:p. I-15] Continuity for COIs is addressed in Part IV of the 1999 Draft TEMP as follows:

> MCOTEA will review each update of the AAAV Program Analysis of Alternatives (AoA, formerly the COEA) and update the TEMP to ensure linkage among COEA/AoA MOEs, the TEMP COIs/ MOEs, and the ORD thresholds. [Ref. 57:p. IV-3]

Finally, the contractor and the DRPM ensure that established requirements are translated into specifications, and that the system, subsystems, and components are tested to meet those specifications. General Dynamics conducted initial requirements analysis from 13 June 1996 when the PDRR phase contract was awarded to 16 April 1997 when the System Design Review (SDR) was conducted. [Ref. 52] The System Requirements

Review (SRR) was held in December 1996, and was used to establish the first System/Segment Specification (S/SS) for the AAAV(P) and the AAAV(C). Changes to requirements in the specification are conducted on an ongoing basis.

General Dynamics also uses data base matrices to track both the requirements validation process and the test planning process. The Requirements Validation Matrix identifies the S/SS by page and number, identifies the responsible IPT, lists the type of validation method (Inspect, Analyze, Demonstrate, Model/Simulate, Test), identifies the level of validation (Component, Subsystem, System), and identifies vehicle weight configuration and environmental condition for testing. [Ref. 52] The Test and Evaluation Validation Matrix has similar content to the Requirements Validation Matrix, but contains greater detail on environmental conditions for testing. The Test and Evaluation Integrated Test Plan was combined by General Dynamics into an Access Data Base that provides linkage between the Work Breakdown Structure (WBS), the Systems Engineering Design Schedule (SEDS), and the S/SS. [Ref. 90] During the System Design Review, the contractor briefed that, "This data base is considered to be the most thorough, detailed, cross-linked and user friendly resource for the Integrated Test Plan CDRL –T016." [Ref. 90]

F. CHAPTER SUMMARY

This chapter established and documented the eleven-year evolution of the AAAV PMO's test and evaluation strategy from Milestone 0 to the present, and the anticipated test and evaluation strategy for the future by analyzing three versions of the program's

Test and Evaluation Master Plan. This chapter provides the foundation for the development and analysis of test and evaluation issues faced by the PMO.

VI. TEST AND EVALUATION RELATED ISSUES AND LESSONS LEARNED

A. INTRODUCTION

This chapter discusses issues facing the AAAV Program Management Office that have had, or will have, impact on the development and conduct of the program's test and evaluation strategy. Where available, the courses of action (COAs) available to the PMO, and the associated advantages and disadvantages of the COAs, are discussed in order to provide potential guidance for other program's facing similar issues. Applicable lessons learned are then developed for each issue. Table 7 outlines the specific issues discussed.

Test Management
Issue: What is the potential impact of down-selection and co-location on the ability of the contractor to provide adequate test and evaluation support to the design and development of the AAAV?
Issue: What working relationship between oversight agencies, external agencies, and the DRPM best serves the PMO's test program?
Developmental Test and Evaluation
Issue: What are the effects of schedule compression on the DRPM's ability to complete all scheduled DT test objectives prior to the AAAV(P) EOA and Milestone II?
Issue: Who is best suited to develop Detailed Test Plans?
Issue: What is appropriate level of detail necessary for Detailed Test Plans?
Operational Test and Evaluation
Issue: What is a sufficient level of operational assessment prior to the conduct of IOT&E?
Issue: What operational issues are truly critical?
Issue: What is the impact on test planning for IOT&E if LRIP vehicles are no longer available?
Issue: How can the DRPM best meet FOF RTCA requirements?
Issue: What if OT events prove system fails to meet operational effectiveness criteria?
Issue: Will USMC structure be in place to properly assess supportability issues with system deployment during IOT&E?
Live Fire Test and Evaluation
Issue: How can an adequate Vulnerability Assessment be conducted for the AAAV(C) variant without a Full Up System Level (FUSL) Test Event?
Issue: What key areas of concern face a Program Management Office when developing a Live Fire Test and Evaluation Strategy?
Requirements
Issue: How does the DRPM's "stop work" decision on the AAAV(C) due to changes in the system's requirements affect the test strategy?
Issue: How does the DRPM best address the interoperability KPP requirement in the Test and Evaluation Master Plan?

Table 7. Summary of AAAV Test and Evaluation Issues.

B. TEST MANAGEMENT

Issues facing the PMO at the test management level fall into two general categories. First, the working relationship between the contractor and the government was significantly effected by the decision to down-select to one contractor in the PDRR Phase, and then to co-locate the DRPM and the contractor in the same facility. Second, the working relationship between the PMO, oversight agencies, and external agencies was effected by the DRPM's decision to "activity engage" each in the decision making process.

1. Down Selection and Co-location

Issue: *What is the potential impact of down-selection and co-location on the ability of the contractor to provide adequate test and evaluation support to the design and development of the AAAV?*

Discussion: The ability of the contractor to support test and evaluation activities is based on the number and caliber of test personnel assigned to the program. The contractor has many options in a co-location environment including: determining which specific skill levels and personnel are to be assigned and relocated to the new facility/project; determining the number of test personnel to be assigned and relocated; and determining the level of matrix support to be provided from the headquarters location to the new project's facility. "The co-location decision must account for segmenting the contractor's test capabilities." [Ref. 91]

Contractor personnel indicated that when the PDRR contract was awarded to GD Land Systems, GD was forced to split out a slice of their test personnel from the Sterling

Heights, Michigan headquarters to send to the newly created GDAMS division in Woodbridge, Virginia. Methods available to the contractor to make personnel relocation decisions include asking for volunteers, directing personnel to relocate, or a combination of volunteering and forced relocation. Concerns with these methods include meeting the required number of test personnel willing to relocate, meeting the required skill levels of test personnel willing to relocate, and hiring new test personnel to meet possible manpower deficiencies resulting from those not willing to relocate. Contractor personnel also indicated that the potential exists for Management to underestimate the level of test experience and diversity of test personnel backgrounds necessary for a system of this scale and complexity. [Ref. 91]

Another concern of co-location is that Contractor Management may not properly assess the manning level of test personnel required for the project. The Test Manager for GDAMS stated that he initially estimated needing at least three personnel for testing, yet "management estimated only half a person." [Ref. 92] The present GDAMS test staffing of four engineers is now seen by the test manager as too few. His main points are that the original estimates of contractor test personnel did not account for the IPT process, and the concurrent testing of three prototypes. "Because test representation is required in all the subsystem IPTs, test section manning levels must account for the IPT process. With a small staff, test personnel can often find themselves attending so many IPT meetings that the time needed for test planning and execution becomes greatly reduced." [Ref. 92]

The number of contractor test personnel also influences the amount of testing that can occur concurrently. With the addition of P2 and P3, the contractor's test manager believes he is reaching the limits of his capabilities to setup, execute, and collect data at multiple locations with the different vehicles conducting different tests. A solution or aid to this potential problem is that the Government has established a small staff of Development Test (DT) Marines to conduct testing with contractor personnel. The present concept is for the contractor to provide two crewmen and the Government to provide two crewmen per prototype during each testing event. The contractor's senior crewmember would serve as crewchief of the test vehicle. This provides the contractor the ability to staff a single test shift on a six-day-a-week basis. However, this team effort would only allow the contractor to staff a double shift for up to two weeks. At that point, fatigue becomes a safety factor and testing would have to return to a single shift. [Ref. 92]

A specific issue for amphibious vehicle testing is that both contractor and Government crewmembers must be scuba dive qualified for water testing safety purposes. This requirement impacts manpower decisions with respect to the number of qualified personnel available to conduct concurrent testing. [Ref. 92]

Lesson: A co-location decision must account for the segmenting of the contractor's test capabilities. Both program management and contractor management must properly assess the number, experience, and skill level of test personnel required for projects based on the level of system complexity. Test section manning levels must also account for the IPT process, the number of test articles, and the level of concurrent testing to occur at different test sites. Test representation will be required in all subsystem level IPTs. [Ref. 92]

Lesson: The IPT process and co-location have been beneficial in the conduct of daily communications with Government counterparts. Neither the implementation of ongoing schedule changes, nor the updating of the test plans in a rapid manner would have occurred without co-location. [Ref. 92]

2. Working Relationships

Issue: *What working relationship between oversight agencies, external agencies, and the DRPM best serves the PMO's test program?*

Discussion: The DRPM faced two general options with respect to the PMO's overall relationship with oversight agencies and other external agencies. From a test and evaluation perspective oversight agencies include DOT&E, DOT&E (LFT), and DS&TS (DT). External agencies include MCCDC, MCOTEA, and Test Sites such as ATC and AVTB. Option One would be to maintain a "report as required" relationship in which the dialog between the PMO, the oversight agencies, and the external agencies would be kept to an essential minimum. Option Two would be to "fully engage" the agencies while maintaining an up-front, forthright, and proactive relationship. [Ref. 93]

The DRPM has chosen to actively engage both the oversight agencies and the external agencies as early in the test planning process as possible. He believes that this inclusiveness better serves to accomplish the program office's mission while still meeting the other agency's requirements. Specifically, both sides can reach a balanced and acceptable level of testing with meaningful test objectives within the realities of the program's fiscal constraints. [Ref. 94]

Lesson: A working relationship should be developed and maintained that "actively engages" both the oversight agencies and the external agencies as early in the test planning process as possible. By gaining a mutual understanding and using the agencies' knowledge and expertise, the program can achieve a greater efficiency in its use of resources. To achieve this efficiency, every effort must be made by both Government and Contractor personnel to optimize their time and resources to ensure an effective test program. This optimization is a mindset, and requires continually assessing the system's requirements and the test objectives to ensure that redundancies are justified or eliminated. True optimization can only occur if oversight and external agencies are "actively engaged" early in the process. [Ref. 94]

3. Other Test Management Lessons Learned

Lesson: The acquisition reform efforts of down selection to one contractor in the PDRR phase, co-location of the Government and the Contractor in the same facility, and implementation of the IPPD/ITP process have proven invaluable to the test planning process. The first two reform measures link directly to the latter, and because they are linked they result in a synergistic effect for the program. Without these combined reform measures the program would not have been successful in planning, coordinating, and conducting other reform measures that meet the DRPM's optimization goals. Integrated

Contractor and Government developmental testing could not have been coordinated, Detailed Test Plans written by the Contractor would not have been acceptable to the test-site agencies, and generation of the Test and Evaluation Management Plan and the Live Fire Test and Evaluation Management Plan would have been unacceptably delayed. [Ref. 93]

Lesson: The Test and Evaluation Working Level IPT is essential for the successful implementation of the program's Test and Evaluation Strategy. The T&E WIPT is a value added management tool that enables enhanced communication, ensures mutual understanding, and prevents confusion among the critical decision makers at the appropriate level. The development of the subordinate LFT&E Working Group has proven successful in meeting OSD oversight requirements. Consideration was made to have similar subordinate Working Groups for Developmental Testing and Operational Testing, but the T&E WIPT determined that these Working Groups might actually decrease effectiveness. Regardless, each Program Management Office must determine the most appropriate Test and Evaluation management plan based on that program's unique needs. [Ref. 97]

Lesson: The emphasis on "empowering" IPT members and making decisions at the lowest possible level makes it difficult to track the decision-making process regarding some issues. Unless the IPT develops and maintains an adequate record of the IPT's discourse during a meeting, the multitude of courses of action (COAs) analyzed and decisions made can not be traced, reviewed, or analyzed over any period of time. Therefore, a record of the decisions and COA analysis should be maintained for future traceability and reference. The IPT group analysis and consensus decision-making process differs significantly from the more formal "staff planning process" used by most military organizations. Unless issues are raised to the DRPM level, seldom are COAs for those issues documented, developed in their entirety, and presented as such for an eventual decision. Military members assigned to a program office need to understand the difference between the IPT decision-making process and the more traditional "staff planning process."

Lesson: The congressional funding plus-ups, the increased procurement of PDRR prototypes, and the schedule acceleration concessions are out of the test manager's control, yet each had a significant impact on his ability to plan, coordinate, and prepare for the conduct of the AAAV's test program. The DRPM's test manager was able to overcome these issues because of his understanding of the DRPM's test strategy and his relationship with other agencies. Thoroughly understanding the DRPM's envisioned end-state for his testing program has allowed the test manager to make necessary short-term changes to the test program based on changing environmental conditions. Additionally, the test manager had a well founded working relationship with the contractor's test manager, the OSD oversight representatives, the requirements officer, the test-site representatives, and the independent operational test director. The combination of a clear test strategy and good working relationships placed the test manager in a better position to maintain an awareness of the program's overall test status, make necessary changes to the test plan, manage the test program, and achieve the system's test objectives.

Lesson: The updating of the AAAV's 1995 TEMP to meet the needs of the Milestone II DAB review was a long and complex process. As the program moves from the PDRR Phase the to EMD Phase, the level of detail in the Draft TEMP increased significantly based on the system's increased maturity level and the increased proximity to actual test events. The PMO has been successful in generating an updated TEMP because of four key decisions. First, the program convened the process as early as possible. Second, the program actively sought input from all OSD oversight agencies especially with respect to Live Fire Test and Evaluation. Third, the program worked closely with the requirements developer to ensure that the ORD update process paralleled the TEMP update ensuring continuity between the two documents. Finally, the program maintained close and constant coordination with the independent operational test director from MCOTEA. This coordination allowed MCOTEA and the DRPM to develop Part IV of the TEMP with a significant level of continuity. By implementing these four decisions, a program management office can reduce the complexity and the time necessary to make TEMP revisions.

C. DEVELOPMENTAL TEST AND EVALUATION

The two main areas of issue facing the DRPM with respect to Developmental Test and Evaluation include schedule constraints that impact the amount of time available to achieve test objectives, and determining the appropriate level of responsibility for generating Detailed Test Plans.

1. Schedule

Congressional funding plus-ups have generally been attached to concessions by the PMO to accelerate the program's schedule. Specific funding enhancements in FY97 and FY98 were tied to the movement forward of Milestone II, Milestone III, and IOC. More recently, the PMO has sought approval to move Milestone II forward from January 2001 to November 2000 in order to reduce the impact of possible delays on the program's progress caused by the Presidential election and political appointment process. Additionally, the first prototype's (P1) readiness to test has been delayed by system integration problems.

Issue: *What are the effects of schedule compression on the DRPM's ability to complete all scheduled DT test objectives prior to the AAAV(P) EOA and Milestone II?*

Discussion: In February 1997, the Operations Officer conducted a T&E Schedule Evaluation brief for the DRPM with the expressed purpose "to determine where 3-4 months can be saved between Prototype #1 delivery and Milestone II." [Ref. 101] Assumptions made at this brief included delivery of P1 on time with minimal contractor shakedown issues, saving time by conducting concurrent contractor and government developmental testing, the availability of OT personnel during the conduct of DT events, and early DOT&E input allowing reduction of the reporting time to under 180 days. [Ref. 101]

The DRPM approved this compression of the test schedule despite increasing the anticipated level of risk. Risk was assessed as "high" regarding P1 delivery and shakedown, and "medium" concerning the reduced amount of time to conduct the EOA even with concurrent DT/OT events and two prototypes. [Ref. 101]

As a result, the Contractor's Test Manager first expressed concerns about insufficient time on the schedule for completing test objectives in October 1997 when test schedule risk was again assessed. Because Contractor and Government developmental testing would be integrated, the test manager indicated that, "This will allow a reduction in the impact to the overall schedule that problems would [create]." [Ref. 98]

In January 1998, the Contractor's Test Manager indicated that the addition of the second and third prototypes should ease, "Our ability to complete all test objectives in the scheduled amount of time…" [Ref. 98] The Contractor's Test Manager also stated that, "The third vehicle gives us the flexibility to increase testing in areas that are behind schedule, or where we have increased concern" [Ref. 98] By February 1999, the contractor had developed single- and double-shift test plans for test delay contingencies. "This escalation of resource utilization has been added to our planning schedule and has been briefed to the Product Design Team and the [DRPM]." [Ref. 98]

The 9 April 1999 virtual design database (VDD) test-schedule risk entry by the contractor states:

> The ability to successfully complete the required testing on time for the DAB review remains as before. P-1 is still scheduled for a 2 August delivery and the current and proposed updated schedules show that the assigned tasks are do-able within the time frame allocated. There is a

> problem with P-2 delivery it has been moved...to mid November and it forces that portion of the testing into a tighter time frame than we would like. The new schedule does show that it is possible to complete, but it allows even less "breathing room" than previously. [Ref. 98]

In late 1998 and again in early 1999, the Contractor's Test Manager briefed his concerns about the test schedule to the DRPM. He described the existing DT schedule as "too tight" and a sure "formula for failure." [Refs. 99, 100] He emphasized that the six-days per week and ten-hours per day schedule was necessary even before adding in any proposed DT/OT integration, and that there was a need to prioritize testing requirements should the schedule not allow completion of all planned test objectives. In order to resolve this concern the Contractor's Test Manger proposed the following [Ref. 99]:

- Look for testing that can otherwise be moved beyond the EOA to increase schedule flexibility.
- Identify DT/OT integration possibilities, especially for the KPPs and Milestone II exit criteria.
- Ensure enough flex time remains in the schedule to account for "Murphy's Law."

During an interview with the author, the Contractor's Test Manager stated that his two primary concerns with the existing test schedule are a lack of built-in maintenance time, and an underestimation of the time necessary to complete full-up system integration. First, the Test Manger believes the present schedule lacks a buffer at the end of each test event to allow for the accomplishment of necessary corrective maintenance to the system. He feels the schedule is based on the assumption that the system will perform without developing faults or problems. He indicated that, based on his experience, between 50% to 60% of the schedule needs to be allotted to maintenance time in order to make system and subsystem repairs during the conduct of DT. He also indicated that, based on his experience, most PM's are not willing to build that into the schedule, or if built into the schedule, the maintenance time is seen as expendable when the program is behind schedule and trying to find time to catch up. [Ref. 92]

Second, the Contractor's Test Manager stated that full-up system integration "always takes longer" than planned for or anticipated. His concern is that despite the program's experience with the ATR and the HTR, the schedule still does not account for the unknown factors. "The AAAV is a revolutionary upgrade in system performance. This aspect of the system even further complicates the integration process and increases possibility for problems in testing." [Ref. 92] He further indicated that the revolutionary aspect of the system's development should be accounted for in the schedule by adding more maintenance time. [Ref. 92]

An additional concern expressed by the Contractor's Test Manager is that the political justification for moving up Milestone II from January 2001 to Nov 2000 only compounds the lack of system readiness for testing at this time. As a point of summary the Test Manager said, "The Milestone keeps moving to the left and the system's readiness for testing keeps slipping to the right. Eventually something will have to give." [Ref. 92]

The DRPM's Test Manger stated that he has already lost six man-months of testing due to the system's lack of readiness at scheduled test periods. He also indicated that the

DT test schedule was designed to accommodate a certain amount of slippage. As an example, the test events for Ft. Story, Virginia focused on testing the system's ability to achieve high water speeds in Sea State 2 or above. Knowing that ocean conditions on the east coast and west coast differ significantly, the program's original goal was to achieve the high water speed in "East Coast" Sea State 2, and then be able to compare that to "West Coast" Sea State 2 at Camp Pendleton, California. At this time, the Ft. Story high water speed testing has been cancelled to accommodate schedule changes, and the high water speed testing will only occur at Camp Pendleton. [Ref. 93]

Working closely with the Contractor Test Manager, the DRPM Test Manger established test objective priorities that would ensure a sufficient level of testing prior to both the scheduled EOA and Milestone II. The test objective priorities are as follows [Ref. 93]:

- Product Definition and Risk Reduction Phase (PDRR) exit criteria.
- Governmental Acceptance Test Criteria.
- Essential Critical Technical Parameters (CTPs) to verify system "safe and ready" for the EOA.
- Remaining Critical Technical Parameters (CTPs) as listed in the TEMP.
- System/Subsystem Specifications.

The time necessary for test agencies to complete their reporting process is an additional concern that impacts the available time prior to the Milestone II decision. A movement of Milestone II to November 2000 would not provide MCOTEA the requisite

120 days to complete their assessment report before the convening of the DAB. Concessions by DOT&E, MCOTEA, and the DRPM will enable the DRPM to enter the DAB process relying on the "Quick Look" report generated by MCOTEA. Traditionally, the Quick Look Report is considered a "close hold" report in which there is limited distribution to MCOTEA, MCCDC, and the Assistant Commandant of the Marine Corps. However, DOT&E as agreed to accept the Quick Look Report as sufficient enough for the Milestone II review. In order to achieve this rapid of a turn around from the completion of testing to the generation of a Quick Look Report, DOT&E and MCOTEA have agreed to conduct concurrent data analysis. [Ref. 78]

Lesson: In order to meet schedule compression and optimization goals, all areas of testing should be reviewed early and with all agencies involved. The results of the DRPM-AAA schedule review included establishing an integrated Contractor and Government Developmental Testing program, increasing the number of combined DT and OT events, and streamlining the Live Fire Test and Evaluation schedule. These efforts allowed the Program Management Office to initiate an accelerated integrated schedule without significantly increasing schedule or performance risk. [Ref. 97] Failure to begin test schedule reviews and involve all agencies as early as possible could result in cost overruns, unacceptable increases in risk, and an inability to meet test schedules.

2. Detailed Test Plans

The two issues facing the DRPM with regard to Detailed Test plans are identifying who is in the best position to develop the DTP, and what level of detail should the DTP contain to meet the requirements of Development Testing for the system.

Issue: *Who is best suited to develop Detailed Test Plans?*

Discussion: In a traditional developmental testing program, the Contractor would develop DTPs for their portion of Contractor specific DT. The PMO would then be responsible for developing DTPs for the Government specific DT. Generally, the PMO would delineate the actual writing of the DTP, or portions of the DTP, to the test-site agency as part of the contract for them to conduct DT test events. As an example, ATC would write the DTP for their portion of Land Mobility testing, and AVTB would write the DTP for their portion of Water Mobility testing. [Ref. 78]

In this case, because the DRPM and GDAMS are conducting integrated Contractor and Government Developmental Testing, the decision was made to have the Contractor write the entire DTP for all phases of the DT-I process. The result was a Detailed Test Plan containing Five Books that exceed 1000 total pages.

Options available to the DRPM included following the "traditional approach," writing the DTP "in-house," or having the Contractor write the DTP as was ultimately decided. Considerations to account for when making this decision include the following:

- Number of Contractor test personnel available to write the DTP.
- Experience of Contractor test personnel with developing and writing DTPs.

- Experience of PMO test personnel with developing and writing DTPs
- Costs associated with the PMO conducting an "in-house" writing of the DTP.
- Costs associated with having the test-site agency write the DTP.
- Time that it would take for each to develop a DTP.
- Quality of the DTP as developed by each.
- Ability to coordinate the development of, and changes to, the DTP with regards to Contractor, Government, and test-site agency locations and IPT processes.

Lesson: The suitability of a specific organization to develop a program's Detailed Test Plan is situationally dependent, and requires an analysis of the above considerations. Regardless of the final decision as to who actually writes the DTP, the Program Manager remains ultimately responsible for the success of the system's developmental testing program.

Issue: *What is appropriate level of detail necessary for Detailed Test Plans?*

Discussion: The contractor's test manager stated that the Government required Detailed Test Plans (DTPs) for DT-I are significantly more detailed than DTPs he has seen used for other programs. The AAAV's DTP for DT-I currently consists of five books totaling over 1000 pages. [Ref. 86] His concern is that the DTPs are so detailed that changes to the schedule cause the contractor to make complete changes to the DTP, where as a less detailed plan may allow for greater flexibility when schedule slippage occurs. The contractor's test manager stated that the Government wanted the expected level of detail to be planned to the day, and in some cases to the hour, even though the planned testing would not occur for almost three years. "This level of required detail so far in advance leads to the counter-productivity of test personnel and their time." [Ref. 92]

The DRPM's Test Manager believes that the DTPs contain a "sufficient" amount of detail for the conduct of integrated Contractor and Government development testing. He indicated, however, that the possibility for reducing the length of the DTPs existed if the commonality between the five books had been separated into a specific executive summary book. The level of redundancy may have been reduced by "30%" had a different format been used. The amount of detail was considered less of an issue by the PMO than by the Contractor. [Ref. 93]

Lesson: Efforts to identify and reduce redundancies in the AAAV's DT-I DTP should have been consistent with the DRPM's efficiency and optimization goals. A Detailed Test Plan's quality is based on its ability to efficiently and effectively allow test personnel to accomplish test objectives and not on its length, volume, or size. Thus, the appropriate level of detail necessary for a DTP is dependent upon the situation of each program.

3. Propulsion System Demonstrator Lessons Learned

The following lessons learned were identified during execution and review of the Propulsion System Demonstrator's (PSD's) developmental testing conducted in the Concept Exploration Phase. The lessons are drawn directly from the June 1994 PSD test report titled, Test and Evaluation of the Propulsion System Demonstrator. They represent, "insights into what could be improved or done differently in future amphibious vehicle development programs...[and] to assist in the design, fabrication, and testing of future advanced amphibious vehicles, Marine Corps systems, and Naval marine craft." [Ref. 65:p. 99] The lessons learned are also applicable to other major defense acquisition programs.

Lesson: "Predicting full scale amphibious vehicle performance, especially high water speed versions, can be accomplished two ways – computer modeling and conducting scaled hydrodynamic model tests. Computer modeling is the least costly alternative, but does not yield a very accurate full scale performance envelope. Scaled model tests on the other hand are slightly more expensive and can accurately predict certain aspects of the full scale vehicle's performance. Some areas of a vehicle's hydrodynamic performance can not be accurately predicted using either computer models or model testing. The general lesson here is that hydrodynamic experiments using scale models are recommended for accurately predicting certain aspects of vehicle performance. Some aspects such as spray and drag which are harder to predict, can at least be identified and minimized from the model tests. Some effects though can only be repeated during full scale trials." [Ref. 65:pp. 112-113]

Lesson: "Developing future combat vehicles requires a very comprehensive and detailed Management Plan. This plan should contain how costs, schedule, manpower allocations, subcontracts, contract documentation, and other aspects of the development effort are to be managed, tracked, and controlled. The PSD program was a follow-on program to both the ATR and the HWSTD development efforts. The scope of PSD was thought to be similar to these previous projects so many of the same management tools were applied. Unfortunately, PSD was a much more complex program because of the major subcontractor involvement, the more critical systems integration requirements, and the added manpower used to perform design, fabrication, and testing tasks. The older management tools were inadequate for handling the larger and more visible PSD program. Planning is the important part of the development process." [Ref. 65:p. 114]

Lesson: "Creating a team environment is essential to getting all personnel who are involved in the effort working effectively and smoothly. The same people who design the systems should follow the work through the fabrication phase and into testing. Contractor design personnel assigned to PSD were the same HWSTD designers. These people were involved with the fabrication and assembly of the hardware, the initial checkout, and were even available for counsel during testing." [Ref. 65:p. 115]

Lesson: There was no written standard operating procedure for safe conduct of full scale high speed hydrodynamic testing. In order for military and Government personnel to operate the PSD, safety procedures and certain physical requirements must be met. Safety Standard Operating Procedures (SOPs) should be prepared that parallel the test plan and sets guidelines and requirements for each hydrodynamic test being performed such as: safety certification, crew and test personnel training level, support and safety equipment, and safe operating criteria. [Ref. 65:p. 115]

Lesson: "No matter how much effort is put into the planning of tests, they always take longer than originally thought. There is nothing that can be done to [completely] eliminate failures and 'Murphy's Law.' However, flexible test plans, contingency procedures, and ample spare parts, resources, and personnel can minimize their impact on the test schedule." [Ref. 65:p. 115]

Lesson: "Future vehicle systems must be designed for easy operation, maintainability, accessibility, and inspection by crew, maintenance, and troop personnel...[Many] areas of the PSD design lacked adequate human factors considerations. The lessons learned regarding human factors were to always design components with their eventual user in mind." Components should be designed for easy operation in a variety of environments, under different conditions and under various operational scenarios. [Ref. 65:p. 116]

4. Other Developmental Test and Evaluation Lessons Learned

Lesson: Early prioritization of Developmental Test events is critical for the conduct of the program's Test and Evaluation strategy. Prioritization of Developmental Testing events allows the program, the oversight agencies, and the test-site agencies to remain focused on the purpose and objective of each test event, and allows for greater flexibility in the conduct of testing should schedule slippage become a problem

D. OPERATIONAL TEST AND EVALUATION

Issues facing the DRPM with respect to Operational Test and Evaluation include the appropriate level of system assessment prior to IOT&E, the development of Critical Operational Issues, the impact of LRIP vehicles on IOT&E, the appropriate methods to conduct FOF RTCA, and present concerns about future operational testing.

1. Early Operational Assessments / Operational Assessments

The 1995 TEMP indicated that once EOA 4 was completed in the beginning of FY02, no other OT event would occur until IOT&E in FY07.

Issue: *What is a sufficient level of operational assessment prior to the conduct of IOT&E?*

Discussion: While reviewing the DRPM's 1999 Draft TEMP in preparation for the Milestone II DAB, DOT&E noted that the five-year lag between the last EOA and IOT&E was unacceptable. The concern was that the program would be unable to enter IOT&E with a known and acceptable level of risk based on the program's original schedule calling for three software updates and one hardware update following EOA 4. Without an OT event to track progress of the system's design prior to IOT&E, DOT&E deemed the risk as, "too high." [Ref. 93]

As a means to resolve the issue DOT&E, MCOTEA, and the DRPM developed an Operational Assessment plan that included adding three OA's to the EMD Phase. The OAs would serve to answer operational effectiveness and suitability issues for extreme weather and lower level unit command and control. The OAs would also serve as preparation and rehearsal for MCOTEA prior to IOT&E. The OAs also allows MCOTEA and the DRPM to reduce the scope of IOT&E. The DRPM's Test Manager believes that by adding the OAs, the PMO will save approximately $36-85M in EMD funding. [Ref. 93]

The second, and possibly most significant, means of reducing the five-year lag between the last EOA and IOT&E resulted from funding and program schedule issues more so than test issues. The trade-off decision by the PM to move Milestone III and IOC from FY08 to FY05 to gain additional funding inherently compressed the time span between the last EOA and IOT&E by two years.

With respect to test specific issues, the options available to the DRPM included relying on the EOA reports and the DT-II results to determine system readiness to enter IOT&E, conducting a limited number of OAs, or conducting the three OAs as finally determined. The disadvantage of not conducting OAs, or having a reduced number of OAs, is that the period between the last Operational Assessment and IOT&E was still deemed too long, and the associated level of risk remained too high. An advantage to conducting the OAs is that MCOTEA will be better prepared to support and conduct IOT&E. Another advantage to having the OAs is that MCOTEA will gain the opportunity to assess the Assault Amphibian School's ability to sufficiently train Marine crews for IOT&E. MCOTEA may also be able to assess the school's ability to sustain sufficient training into the future for IOC and FOC.

Lesson: The use of multiple EOAs in the Concept Exploration Phase and the Program Definition and Risk Reduction Phase, and the use of OAs in the Engineering and Manufacturing Phase results in early and constant user input to system design and development. Thus, the associated performance risk as the system enters IOT&E is significantly reduced. Five years between a final EOA and IOT&E without an operational assessment may raise performance risk to unacceptable levels.

2. Critical Operational Issues (COIs)

The 1995 TEMP lists three Operational Effectiveness COIs and five Operational Suitability COIs for the generic AAAV system. It further delineates three unique COIs for the AAAV(P) variant and two COIs unique to the AAAV(C) variant.

Issue: *What operational issues are truly critical?*

Discussion: Though sufficient for the 1995 TEMP, OSD directed that MCOTEA and the DRPM review and change those COIs for the 1999 Draft TEMP. The original COIs, as listed in the 1995 TEMP, were seen by DOT&E as not distinguishing between operational issues and critical operational issues (See Chapter V, pp. 58-59). As the DRPM's Test Manager stated, "Not all operational issues are critical." [Ref. 93]

In order to review the intent of the original COIs and develop more meaningful COIs, MCOTEA established a temporary IPT in May and June of 1999 with members from the DRPM, MCCDC, and MCOTEA. The IPT was able to reduce the number of AAAV operational issues to the two effectiveness COIs and one suitability COI listed in Chapter V, page 60. These COIs were determined to be truly critical. [Ref. 93]

Lesson: The use of an IPT to determine critical operational issues is successful when representatives from requirements development, the independent operational test activity, the PMO, and DOT&E are participating members. The number of COIs is less important than the relevance of the COIs, and the ability to generate associated Measures of Effectiveness and Measures of Performance needed to resolve the operational effectiveness and suitability issues.

3. Test Article Availability

Higher level funding issues dictated that the LRIP production schedule be adjusted. First, the start date for LRIP production was delayed as a concession to other Marine Corps programs. Specifically, the LRIP delay allowed the Marine Corps to take approximately one year's worth of AAAV early production money and redistribute it to other programs allowing those programs to finish their annual buy. This shift of funds reduced the overlap of multiple programs' funding and was the easiest for the Marine Corps to accomplish. Second, the DRPM shifted the LRIP start date to a later date to better accommodate a more stable manpower need by the contractor. Finally, the LRIP finish date was moved up in order to meet the newly accelerated program schedule.

Issue: *What is the impact on test planning for IOT&E if LRIP vehicles are no longer available?*

Discussion: The compressed LRIP schedule resulted in a dilemma for the DRPM. The four LRIP vehicles previously planned for use in the IOT&E FOF RTCA phase would no longer be available. As a result, the DRPM was limited to two basic options. First, move the Milestone III DAB review to a later period. This option was seen as untenable based on Congress' desire to have the program accelerate its integrated schedule. The second option was a combination of increasing the number of operational assessments to ensure that a high quality vehicle would enter IOT&E, and adding an FOT&E event to resolve potential operational suitability questions. [Ref. 93]

The PMO determined that having eight AAAV(P) production EMD prototypes and one AAAV(C) production EMD prototype was an acceptable combination of vehicles for IOT&E if employed as a mechanized team with a tank platoon. DOT&E concurred that the mechanized team concept would be sufficient for answering operational effectiveness questions, but was not convinced that operational suitability questions could be answered. The decision to add an FOT&E event for LRIP vehicles was based on this concern, and would include increasing the confidence of the system's reliability and availability. [Ref. 93]

Lesson: Maturity of the system's design throughout the CE Phase, the PDRR Phase, and into the EMD Phase effects a PM's ability to have production representative EMD prototypes available for IOT&E. Programs not able to meet the same level of system design maturity as the AAAV early in the system's lifecycle may not be able to successfully plan for or execute IOT&E without the use of LRIP vehicles. A lack of LRIP vehicles could impact the total number of test articles available for use in IOT&E. A reduced number of test articles will impact IOT&E planning especially if the number falls below a doctrinal unit set.

4. Force-On-Force Real Time Casualty Assessment

Two conditions faced the DRPM with respect to Force-on-Force (FOF) Real Time Casualty Assessment (RTCA). First, the U. S. Army lost its primary FOF RTCA facility at Ft. Hunter-Liggett, California to Base Realignment and Closure (BRAC) decisions. Second, DOT&E had stated concerns about insufficient FOF RTCA detail in their comments about the DRPM's 1995 TEMP. "Prior to Milestone II, the Marine Corps must develop a scoring system that provides an effective method of measuring force on force evaluations with real time casualty assessment and vehicle removable from the battlefield." [Ref. 82]

Issue: *How can the DRPM best meet FOF RTCA requirements?*

Discussion: The DRPM's Test Manager expressed concerns about not only meeting the FOF RCTA requirement, but also how to meet the requirements without incurring significant costs. The two primary alternatives available to the DRPM included use of the Army's National Training Center (NTC) facility at Ft Irwin, California, or use of existing Marine Corps Combined Arms Exercise (CAX) Program controller personnel. Aiding in the DRPM's decision was DOT&E's view that the Marine Corps should conduct FOF RTCA in a way that would gain the necessary information in an environment conducive to the Marine Corps' capabilities. As a result, the FOF RTCA phase of IOT&E will be conducted at 29 Palms, California with CAX personnel providing controller and evaluator support while U. S. Army Test and Experimentation Command personnel provide planning, executing, scoring, and reporting assistance. The

Test Manager's belief is that a Marine Corps run FOF RTCA evolution, though more manpower intensive and less technologically sophisticated than a similar Army evolution, will force the Marine Corps to concentrate on critical data collection requirements. This concentration of effort would prevent over-collection of unnecessary data, reduce associated costs of conducting an FOF RTCA, and provide more realistic and meaningful conclusions about the AAAV's performance in a force-on-force environment. [Ref. 93]

Despite the compromise between sophistication and cost, the 1999 Draft TEMP still states the following concerns with respect to expense:

> The lack of adequate in-service testing capability will require the Marine Corps to rely on Army testing assets, and drive up testing costs. The prohibitive cost of each FOF RTCA evolution will also limit the total number of OMPs that are scored. However, the number of AAAV FOF RTCA profiles and engagements is consistent with testing for the Bradley Fighting Vehicle, and should therefore provide an adequate test. [Ref. 57:p. IV-26]

Lesson: To best meet FOF RTCA requirements, a close working relationship between the PM, DOT&E and the independent operational test agency should be established in order to develop the scope of the test, to determine the data necessary to conduct FOF RTCA analysis, and to optimize the data collection efforts. Open and continuous communication with DOT&E and MCOTEA will allow a PMO to meet DOT&E FOF RTCA requirements while minimizing associated costs.

5. Potential Operational Issues

The following two items were expressed as concerns by the Assistant Program Manager for the AAAV(P) as potential issues that could impact the PMO based on the results of OT events, or based on a lack of preparedness for OT events.

Issue: *What if OT events prove the system fails to meet operational effectiveness criteria?*

Discussion: The Assistant Program Manager for the AAAV(P) expressed a concern that should the AAAV(P) fail to meet operational effectiveness issues, then the PMO will be put in a position to use the OT event results as a basis for future trade-off studies. The primary area of performance risk that the program faces is maintaining weight at an acceptable level to allow the vehicle to achieve high water speed. Though finally ranked as "medium" by the ONR, exceeding weight predictions was a consistent theme throughout each of their three technical risk assessments. The basis for the trade-off studies would be which subsystems are essential and which subsystems are “nice to have.” [Ref. 97]

Lesson: Failure to meet operational effectiveness during OT events can force a program into system requirement trade-off studies. Anticipating this problem and developing pre-planned courses of action for trade-off analysis can minimize the overall impact on the system’s development. Pre-planning of trade-off analysis should include representatives from requirements development and the Fleet to ensure maximum user input to the decision making process.

Issue: *Will USMC structure be in place to properly assess supportability issues with system deployment during IOT&E?*

Discussion: The second concern or future potential issue involves system support structure readiness for IOT&E. Specifically, the concern is whether the Marine Corps will have sufficiently evolved its concepts of Sea Based Logistics, Over the Horizon doctrine and tactics, and two-echelon maintenance support for application during the IOT&E of the AAAV. [Ref. 97]

Lesson: Failure to have these concepts fully developed and ready to support IOT&E could lead to inaccurate or inconclusive evaluation of the system's operational effectiveness and suitability.

6. Other Operational Test and Evaluation Lessons Learned

Lesson: Early prioritization of Operational Test events is critical for the conduct of the program's Test and Evaluation strategy. Prioritization of Operational Testing events ensures the program, the independent test agency, and the oversight agencies have common expectations of the OT event. This is especially true with respect to Early Operational Assessments. The program is responsible for ensuring that everyone has common expectations about the assessments from the EOA event. Common expectations also prevent over optimism about a system's capabilities during the conduct of the EOA. Over optimism before the EOA could result in the perception by oversight agencies that "poor performance in an EOA equals a bad program." [Ref. 97]

E. LIVE FIRE TEST AND EVALUATION

The two primary issues facing the DRPM with respect to Life Fire Test and Evaluation are the DOT&E concerns over Live Fire Testing of the AAAV(C) variant to support a comprehensive Vulnerability Assessment, and the development of a thorough and sufficient LFT&E management plan.

1. AAAV(C) Full Up System Level (FUSL) Testing

Current plans for FUSL testing of the AAAV only include using two AAAV(P) production representative EMD prototypes. [Ref. 57:p. IV-28] The 1999 Draft TEMP specifically states, "In the case of the AAAV(C), system ballistic performance will be leveraged from the AAAV(P) Full Up System Level (FUSL) testing." [Ref. 57:p. IV-17] The Draft TEMP further states, "Assessment of the AAAV(C) crew and system survivability will be made through applying results of the AAAV(P) testing and results of AAAV(C) specific component, subsystem and controlled damage testing." [Ref. 57:p. IV-31]

Issue: *How can an adequate Vulnerability Assessment be conducted for the AAAV(C) variant without a Full Up System Level (FUSL) Test Event?*

Discussion: The DRPM's Test Manager indicates that DOT&E (LFT) does not believe FUSL testing of the AAAV (P) satisfies the requirements for the AAAV (C) Live Fire testing. DOT&E (LFT)'s view is that the Live Fire model used for the AAAV(P), and thus the empirical data gained from that model, does not provide a thorough enough vulnerability assessment for the AAAV(C). DOT&E (LFT)'s primary concern is not with penetration effects of threat weapon systems on the hull of the AAAV(C), but with the shock attenuation effects through the vehicle's hull and the subsequent impact on associated communication equipment. As a result of these concerns, DOT&E (LFT) has expressed that they would not necessarily concur with the PM's Vulnerability Assessment Report (VAR). [Ref. 93]

The DRPM is presently assessing three options that will satisfy DOT&E (LFT) concerns. Option One would be to improve the AAAV(P) variant's model generated data by changing or altering the shots and shot angles against the AAAV(P). These new shots and shot angles would be determined based on their ability to generate data collection for model improvements. Thus, the improved model would allow for better estimates of the AAAV(C) variant's vulnerabilities. The advantage to this option is that even if model improvements do not completely assess the AAAV(C)'s vulnerabilities, the improvements may at least be to a level sufficient to satisfy DOT&E (LFT) concerns. It is also the cheapest of the three options. The disadvantage to Option One is that the necessary vulnerability assessment may not be met even with the changes to shots and shot angles on the AAAV(P). [Ref. 93]

Option Two would be to conduct non-penetrating shock testing on the AAAV(C) pre-production configuration to get the necessary vulnerability data. The advantage to this option would be that the necessary data for a thorough assessment of the AAAV(C) variant's shock vulnerabilities could be collected. The primary disadvantage to this option is that this Live Fire testing would occur on the only AAAV(C) prior to IOT&E,

and thus if the AAAV(C) sustained damage during the shock testing, it would be unavailable for IOT&E. Another disadvantage is the increased costs associated with conducting non-penetrating shock testing on the AAAV(C). [Ref. 93]

Option Three would be to contract and build another AAAV(C) production representative prototype that would then undergo complete FUSL. The advantage to this option is that it provides the most complete vulnerability assessment of the AAAV(C). The disadvantage is the increased cost of building another AAAV(C), and the increased costs associated with FUSL testing. It remains undetermined at this time if the AAAV(C) FUSL would be in addition to the two AAAV(P)'s scheduled for FUSL, or in place of one of the AAAV(P)s. [Ref. 93]

Lesson: Vulnerability Assessments methods for Mission Role Variants (MRVs) can become an area of dispute between Live Fire Test oversight agencies seeking to meet Congressional directives and PM's seeking to reduce program cost and performance risk. Determining "adequate" Vulnerability Assessment methods for a specific MRV is dependent upon two things. First is the degree of difference between the primary system undergoing FUSL and the designated MRV. Second, adequacy depends on the ability of the PM and the Live Fire Test oversight agency to reach a mutual understanding of system vulnerabilities in a realistic operating environment.

2. Live Fire Test and Evaluation (LFT&E) Management Planning

The DRPM determined that the best means to document and manage his Live Fire Test and Evaluation (LFT&E) program was to outline the overall plan in the TEMP, develop a specific LFT&E Management Plan to cover LFT&E issues, and have a separate and subordinate Survivability Management Plan that covered specific survivability issues.

Issue: *What key areas of concern face a Program Management Office when developing a Live Fire Test and Evaluation Strategy?*

Discussion: Based on the DRPM-AAA's experience with developing a separate LFT&E Management Plan, six areas of concern face the PMO. Specifically, DOT&E and DOT&E (LFT) identified six general deficiencies that existed in the second draft of the DRPM's LFT&E Management Plan. First, the LFT&E Management Plan did not describe in sufficient enough detail the test schedule of major test events. "The current version shows only bands of activity. Without such a schedule, the ability to execute the plan cannot be judged." [Ref. 102] DOT&E's recommendation was to add detail to the schedule.

Second, "A major flaw in the plan is that it treats only the final FUSL phase as the LFT required by Congress, an incorrect inference that leads to some strange results." [Ref. 102] DOT&E's primary concern with this inference is the delegation of duties throughout the Live Fire process. Specifically, the DRPM is to chair the LFT&E Working Group, a subordinate group of the T&E IPT, for all LFT&E testing prior to

FUSL. Then, MCOTEA would be responsible for chairing the LFT&E Working Group during FUSL. DOT&E states, "As independent evaluator, MCOTEA should chair the working group during the development and approval of the management plan *and* during all phases of test execution (as is the case for Army combat vehicles)." [Ref. 102]

The third DOT&E concern is that the LFT&E Management Plan fails to address the lethality of the program's 30mm ammunition. "The quantities of ammunition to be procured meet the threshold for LFT&E." [Ref. 102] DOT&E's recommendation is to add appropriate lethality sections to both the LFT&E Management Plan and the TEMP update.

Fourth, DOT&E states that the issues of susceptibility, vulnerability, and Battle Damage Assessment and Repair (BDAR) are "too focused on technical requirements" and not on operational requirements. [Ref. 102] "As written, several sub-issues are too requirement-specific, and they mix criteria with statements of issues." [Ref. 102] DOT&E then goes on to give a recommended set of vulnerability and BDAR issues.

The fifth area of concern is the LFT&E Management Plan's lack of clarity about roles and responsibilities related to the program's Modeling and Simulation (M&S) plan supporting LFT&E. The draft Charter for the LFT&E Working Group indicates that GDAMS will have responsibility for planning, conducting, and reporting the results of the M&S efforts that define the AAAV's vulnerability. DOT&E states that, "This seems to give the systems contractor a major role in assessing the vulnerability of his own product." [Ref. 102] DOT&E then recommends that M&S roles and responsibilities be clearly delineated in the LFT&E Management Plan.

The final concern expressed by DOT&E again relates to GDAMS role in LFT&E.

> The LFT&E Management Plan contains a draft LFT&E WG charter that gives GDAMS the responsibility to plan, conduct, and report on the validation testing of various AAAV armors, which is intended to demonstrate that the ballistic requirements of the armors have been met. Unless there is substantial Government oversight of this test, conflict of interest could be an issue. [Ref. 102]

A DOT&E supporting contractor representative from the Institute for Defense Analysis (IDA) provided additional comments concerning the DRPM's Draft LFT&E Management Plan. The representative's primary comments focused on the scope and detail of the plan, and on LFT&E Modeling and Simulation.

First, "The purpose of the LFT&E Management Plan is not clear." [Ref. 103] The IDA representative specifically states, "The draft Management Plan contains a number of susceptibility issues, which are not usually included in LFT&E. Also, there is probably excessive detail about specification compliance testing, normally addressed specifically as part of developmental testing (DT)." [Ref. 103] It is this "excessive detail on irrelevant subjects", and "insufficient detail on required subjects" that raises the concern about the LFT&E Management Plan's purpose. [Ref. 103]

Second, the IDA representative links the first concern with specific details. Sufficient detail in the areas of schedule, resources, component and subsystem testing, and threat shot selection procedures for FUSL are considered "clearly lacking." [Ref.

103] Additionally, susceptibility and specification compliance testing is considered "not directly relevant to the LFT&E effort." [Ref. 103]

Finally, the IDA representative concludes that the LFT&E Management Plan contains too many different references to M&S throughout the entire document without sufficient detail. The recommendation is that, "References to M&S should be consolidated into a single section devoted to the subject." [Ref. 103] The recommendation specifies that the M&S section should contain the following [Ref. 103]:

- An outline of the overall application of M&S.
- How M&S supports the vulnerability or lethality evaluation.
- What specific models are to be proposed.
- What organization operates and supports the models.
- What the model's capabilities and limitations are.
- What the Verification, Validation, and Accreditation (VV&A) strategy is for each model.

Part of DOT&E's concern over the LFT&E Management Plan's content related to whether the document would or would not be on the formal document approval list. DOT&E felt that the LFT&E Management Plan should be a formally approved document if the TEMP's description of Live Fire remained unchanged. This belief was based on the perception that the TEMP would contain only an LFT&E overview and that the LFT&E Management Plan would contain the specifics. In such case, the Management

Plan would need to incorporate the specific detailed comments made by both IDA and DOT&E. [Ref. 104]

The PMO saw no advantage to making the LFT&E Management Plan a formal document requiring DOT&E signature. They saw the disadvantage as reducing the PMO's ability to make changes to the LFT&E Management Plan, and increasing the "stovepipe" effect on the planning process. The PMO felt the LFT&E Management Plan was simply a tool for the LFT&E Working Group, and because DOT&E had membership on the Working Group that formal approval was not necessary. [Ref. 104]

The PMO believed that the advantage to keeping the LFT&E Management Plan an informal working document was that minor and near term changes could be made by the T&E IPT without processing through the formal documentation process. The disadvantage to keeping the LFT&E Management Plan informal was that the TEMP's LFT&E section would need significant improvement in scope and detail. [Ref. 104]

The T&E IPT ultimately determined that the TEMP's LFT&E content would be improved, the LFT&E Management Plan would remain an informal working document for the LFT&E Working Group, and the Detailed Test Plan for LF testing would be a formal document requiring DOT&E signature. [Ref. 104]

Lesson: Coordination between the PMO and DOT&E(LFT) is critical for the development of a Live Fire Test and Evaluation Management Plan. Additionally, the PMO needs to have a clear understanding of its LFT&E objectives prior to determining the most appropriate management plan method.

F. REQUIREMENTS

Changes in requirements for the AAAV(C) by MCCDC and a recent mandate for the inclusion of an Interoperability KPP by the Joint Chiefs of Staff have presented the DRPM with two issues.

1. AAAV(C) Requirements

The release of the AAAV(C) Concept of Employment by MCCDC in January 1997 led to the DRPM's decision to stop work on General Dynamic's development of the AAAV(C).

Issue: *How does the DRPM's "stop work" decision on the AAAV(C) due to changes in the system's requirements affect the test strategy?*

Discussion: The original test concept called for the AAAV(P) and the AAAV(C) to undergo testing on a parallel track throughout DT-I, DT-II, the various EOAs, and into IOT&E. However, the "stop work" decision forced the testing of the AAAV(C) to occur in an off-cycle from the AAAV(P). The repercussions were that scheduled EOAs where either cancelled in their entirety, or restructured and shifted to a later period in the schedule. Additionally, Operational Assessments were added to partially compensate for the loss of AAAV(C) related EOAs (See Appendix D and E).

The DRPM's Test Manager identified the disadvantage of offset testing of the AAAV(C) and AAAV(P) as that test planning and conduct efforts now requires duplication of effort on the part of the DRPM and MCOTEA. Also, OSD oversight managers now view the separated test events as adding to the complexity of the program's test strategy, and thereby increasing the associated risk of not successfully meeting cost, schedule, and performance requirements. [Ref. 93] The DOT&E representative even stated that he believed the development and successful testing of the AAAV(C) variant, "was the high-risk area to the program and the Marine Corps' entire OMFTS concept." [Ref. 96]

Advantages to the offset testing of the two variants include a more stable and even distribution of test personnel requirements over the entire test period. Instead of surging test personnel for one two-variant DT-I evolution, the DRPM and GDAMS can maintain a reduced number of test personnel spread over two one-variant DT-I evolutions. Additionally, the two separate test events allow for a better isolation of system malfunctions during testing. By waiting approximately 12 months to conduct the AAAV(C) DT-I, the basic AAAV system design will be more mature. This maturity will allow testers and engineers to better isolate faults caused by the newly integrated communications suite vice faults occurring in the basic system. [Ref. 93]

DOT&E expressed two primary concerns after reviewing the DRPM's offset test plan in November 1998. First, the Operational Assessments did not appear to support specific program or technical decision points. DOT&E's guidance to correct this problem was that, "The testing schedule should be revised to clearly show the linkage to, and support of, major program or technical milestones (such as Critical Design Review)." [Ref. 95] DOT&E also recommended improving the linkage to program milestone decisions or the related technical engineering milestones which would use the test results to influence design. This leads to DOT&E's second concern that the compressed time to produce an AAAV(C) mockup and the EMD design effort, "...increases the risk of influencing redesign vice design..." of the vehicle. [Ref. 96]

DOT&E also accepted the PMO's view that IOT&E should focus on the AAAV(C)'s unique command aspects. The remainder of the AAAV(C) characteristics can then be estimated by regression testing from AAAV(P) characteristics in order to reduce risk on those characteristics. [Ref. 96]

Lesson: The affect on a PM's test strategy based on requirement changes to the primary system could be significant, and would generally require a detailed analysis of each cases circumstances. The changing requirements for the AAAV(C) variant did not significantly affect test strategy development. Impact was minimized because the AAAV(C) is a Mission Role Variant of the primary system to which there were no requirement changes. In all cases, requirement changes should be kept to a minimum when ever possible.

2. Interoperability KPP

The recently released CJCSI 3170.01A Requirements Generation System, 10 August 1999, mandates in Enclosure E that, "Information Exchange Requirements (IERs) are to be used as the primary basis and measure for system interoperability in defining Interoperability KPP threshold (T) and objective (O) requirements for ORDs..." [Ref. 95] CJCSI 3170.01A further outlines the connection between the Joint Pub 1-02 definition of interoperability and the interoperability KPP requirement as follows:

> Joint Pub 1-02 definition (2) for interoperability defines it as the condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. Even though there are many facets of interoperability (e.g., fuel, ammunition, transportation, communications) that need to be identified in the ORD the focus for the interoperability ORD KPP will be the information exchange and interoperability level for the ORD system information needs. The intent is for the warfighter to outline the essential information exchange requirements for the system as described above. The requirements should reflect both the information needs necessary to satisfy the system under consideration and the information this new capability can provide to enhance fielded systems. The development of the information exchange requirements should cover both the communication requirements for command and control of the proposed system and the level of integration for cross system operations... ORDs will have an Interoperability KPP. [Ref. 95]

Issue: *How does the DRPM best address the interoperability KPP requirement in the Test and Evaluation Master Plan?*

Discussion: The AAAV's current interoperability requirements are outlined in the Critical Technical Parameters listed in the 1995 TEMP. However, the DRPM's Test Manager indicated that JROC desires the required Interoperability KPP to be listed as a Critical Operational Issue with corresponding Measures of Effectiveness and Measures of Performance. The DRPM's Test Manager initially added interoperability as an MOP to the MOE and MOP Testable Criteria Relationships Matrix in the 1999 Draft TEMP (See Table 4, Chapter 5). The interoperability MOPs where then deleted from the Draft TEMP because of a lack of guidance on exactly how to measure and quantify interoperability with respect to communications-electronics equipment. [Ref. 93]

The PMO's specific concern is how to quantify the acceptable levels of degradation in the AAAV(C)'s capability verses a stationary or better-equipped Command Post configuration. Other concerns about the interoperability KPP requirement is the lack of distinction between addressing interoperability in the CTPs and addressing interoperability in the COIs. The Test Manager believes that the revised COIs already address interoperability with specific references to "...an AAAV-equipped amphibious force support[ing] the Navy-Marine Corps Team's concept of an Over-The-Horizon (OTH) amphibious assault..." The issue remains how best then to address interoperability as an MOE and MOP without further guidance from either MCCDC or JCS.

The present resolution to the interoperability issue is to include a description of Joint Interoperability Test Command (JITC) involvement in interoperability KPP development in the Draft TEMP's Part III – Developmental Test and Evaluation Outline. Additionally, the current references to interoperability in the CTPs will be deleted from the final version of the 1999 TEMP (See Appendix I). Of the five interoperability CTPs listed, four did not specifically relate to interoperability as defined and used in CJCSI 3170.01A. The PMO continues to work with MCCDC, MCOTEA, and JITC to refine interoperability MOEs and MOPs for inclusion in future changes to the TEMP. [Ref. 93]

Lesson: The requirement to include an interoperability KPP in the ORD has created confusion at the Test Manager level. Translation of the requirement into MOEs and MOPs for development and incorporation into specific test events is proving to be difficult. Planned coordination with JITC may result in a better understanding of the interoperability KPP requirement, and its subsequent translation into MOEs and MOPs.

3. Other Requirements Lessons Learned

Lesson: It is essential that the initial Operational Requirements Document (ORD) be drafted thoroughly, and be written in such a manner that it allows for testability. A well-prepared and thorough ORD establishes clarity for the user, the Program Manager, the Contractor, the Test Managers, and the Testing Agencies. In order for the ORD to achieve this level of thoroughness, all interested parties need to be involved in its development through the IPT process as early as possible. Failure to do so creates confusion among the interested parties, results in conflicting perceptions as to the system's true requirements, and prevents optimization of the test schedule. [Ref. 94]

G. OTHER LESSONS LEARNED

Lesson: Cost and schedule are two parameters that should be analyzed extensively for risk. Adding funding to the program to allow building of additional prototypes or increasing test resources can aid in mitigating schedule risk. However, the program will reach a point when schedule risk can no longer be countered with funding increases. It is important to assess ahead of time when that culminating point will occur, and have contingencies for mitigating increased risk without added funding. With respect to cost risk, maintaining a stable test budget significantly aids in achieving and maintaining acceptable levels of risk. A cut to the test budget in order to apply funds to other program areas is a sure means of escalating risk to an unacceptable level. [Ref. 93]

Lesson: Do not overlook the importance of Environmental Impact issues on test planning. Areas to consider during test planning include animal migratory patterns and periods, designated species' breeding seasons, and seasonal human activities such as peak boating or fishing periods. Test planners must assess the impact of these type activities on both the primary test schedule and alternate test schedules. These activities could even result in the elimination of certain test objectives because of the increased costs to delay testing until an acceptable period. Information about these issues must be sought by the program management office, and coordinated with the test-site and base range control personnel. As an example, the AAAV PMO spent $16,000 on an Environmental Impact assessment for the planned open-ocean high water speed test events, yet the Ft. Story tests were cancelled because of schedule slippage. However, had the Environmental Impact assessment not been conducted, the program would not have been able to plan any testing at Ft. Story. Environmental Impact assessments and requirements must be reviewed and planned for in a "worst case" scenario in order to mitigate its impact on test planning and schedule risk. [Ref. 93]

Lesson: Field support is critical when test personnel are away from the contractor facility and in the field actually testing the system. Too often the higher level supervisors have an "out of sight, out of mind" mentality. This causes delays with the continuation of testing when the system needs corrective maintenance. One solution to meet this concern, is the contractor's development and use of a "virtual co-location" system.

Television and Computer up-links will be used to keep higher supervisory personnel in real time or near-real time contact with test personnel in the field. Virtual co-location will also allow engineers at the facility to actually observe when and how the system performed or failed to perform. Faster electronic data transformation and video/TV viewing of an actual malfunction allows engineers to identify both short-term and long-term solutions for corrective actions in order to get the system returned to operating condition. Generally, long-term solutions are much different than short-term solutions and the contractor beliefs that "The sooner action is taken, the sooner design corrections can be implemented for continuation of future testing and improvement of system design." [Ref. 92]

Lesson: Having experienced Assault Amphibian Officers as MCOTEA's AAAV Operational Test Director, MCCDC's AAAV Requirements Action Officer, AVTB's Director and Logistics Officer, and throughout the entire DRPM Office results in a clear understanding by all elements of the acquisition process as to the needs of the user. This common understanding also serves to reduce confusion between the separate agencies, allows for faster decision making, and may ultimately result in a better designed system that meets user requirements.

F. CHAPTER SUMMARY

This chapter analyzed and discussed those issues facing the AAAV Program Management Office that had, or potentially have, an impact on the development and conduct of the program's test and evaluation strategy. Where available, the courses of action (COAs) available to the PMO, and the associated advantages and disadvantages of the COAs, were included. Applicable lessons learned were then presented for each issue in order to provide potential guidance for other program's facing similar issues.

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VII. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

The objective of this thesis was to examine the evolution of the AAAV Program Management Office's test and evaluation strategy from Milestone 0 to the present. The goals were: (1) to analyze test and evaluation issues facing the Program Management Office, (2) determine the effects of the issues on the program's test strategy, and (3) develop applicable lessons for other major defense acquisition programs.

Research involved reviewing the evolution of amphibious doctrine and the subsequent evolution of amphibious vehicles to support that doctrine, reviewing the DoD Acquisition Process and the role of Test and Evaluation in that Acquisition Process, and then analyzing three DRPM-AAA Test and Evaluation Master Plans.

General and specific conclusions are provided about the evolution of the DRPM's test and evaluation strategy and the issues that effected its development and execution. Specific recommendations are provided for other Major Defense Acquisition Programs, and recommended future research questions are proposed.

B. CONCLUSIONS

1. General Conclusions

Test and Evaluation Strategy: The Test and Evaluation Strategy for the DRPM-AAA remained stable and consistent throughout the eleven-year period from Milestone 0 to the present. This strategy stability is attributed to the continuity of the AAAV's Key Performance Parameters (KPPs). The desired performance characteristics for an amphibious vehicle began even prior to the establishment of the AAAV program office, and have remained essentially unchanged for nearly twenty years. Because of this, program office test personnel were able to establish clear and concise goals for the conduct of the program's test efforts.

Lesson Applicability: The lessons learned from analysis of the DRPM-AAA's Test and Evaluation Strategy are applicable to most major defense acquisition programs and should be applied accordingly.

2. Specific Conclusions

Developmental Test Strategy: The DRPM's Developmental Test Strategy has remained consistent throughout the program. The DT strategy is: To confirm the AAAV's technical performance characteristics, to determine the feasibility of selected system/sub-system or component technical design, to determine the degree of risks, and to initially assess logistical supportability, reliability, and maintainability of the system. This has allowed the program to maintain its developmental testing focus without becoming distracted by higher level issues.

Operational Test Strategy: The DRPM's Operational Test Strategy has remained consistant throughout the program. The OT strategy is: To determine if the AAAV meets minimum operational effectiveness and operational suitability requirements appearing in the approved ORD by evaluating the AAAV's performance during EOAs, OAs, IOT&E, LFT&E, and selected DT events in order to support acquisition decisions.

Despite changes in the program's funding, schedule, and AAAV(C) requirements, the stable OT strategy has given the program the flexibility to modify and cancel EOAs, add OAs, and refine IOT&E events in order to adapt to a changing environment.

Acquisition Reform: The acquisition reform efforts of down selection to one contractor in the PDRR phase, co-location of the Government and the Contractor in the same facility, and implementation of the IPPD/ITP process have proven invaluable to the test planning process. The first two reform measures are linked directly to the latter, and have resulted in a synergistic effect for the program. Without these combined reform measures the program would not have been successful in planning, coordinating, and conducting other reform measures that meet the DRPM's optimization goal. Integrated Contractor and Government developmental testing could not have been coordinated, Detailed Test Plans written by the Contractor would not have been acceptable to the test-site agencies, and generation of the Test and Evaluation Management Plan and the Live Fire Test and Evaluation Management Plan would have been unacceptably delayed without these acquisition reform measures.

Working Relationships: The DRPM's decision to develop and maintain a working relationship that "actively engages" both the oversight agencies and the external agencies early in the test planning process served three functions. First, the inclusiveness mind-set allowed the program office to accomplish its mission while still meeting the other agency's requirements. Second, by using the agencies' knowledge and expertise, the program is achieving a greater efficiency in its use of test resources. Finally, both sides can continue to reach balanced and acceptable levels of testing within the realities of the program's fiscal constraints.

Test Manager: The congressional funding plus-ups, the increased procurement of PDRR prototypes, and the schedule acceleration concessions were out of the test manager's control, yet each had a significant impact on his ability to plan, coordinate, and prepare for the conduct of the AAAV's test program. The DRPM's test manager was able to overcome these issues because of his understanding of the DRPM's test strategy and his relationship with other agencies. The combination of a clear test strategy and good working relationships placed the test manager in a better position to maintain an awareness of the program's overall test status, make necessary changes to the test plan, manage the test program, and achieve system test objectives.

Optimization: The DRPM has made every effort to optimize Government and Contractor time and resources to ensure an efficient and effective test program. This optimization mind-set was established by the DRPM in conjunction with Acquisition Reform efforts, and has resulted in the program continually assessing the system's requirements and the test objectives to ensure that redundancies are justified or eliminated. True optimization would not be possible if oversight and external agencies had not been "actively engaged" early in the process.

T&E WIPT: The Test and Evaluation Working-Level IPT is proving essential for the successful implementation of the program's Test and Evaluation Strategy. The T&E WIPT is a "value added" management tool that enables enhanced communication, ensures mutual understanding, and prevents confusion among the critical decision makers at the appropriate level. The DRPM's development of a subordinate LFT&E Working Group has proven successful in meeting OSD oversight requirements. Considerations to implement similar subordinate Working Groups for Developmental Testing and Operational Testing are situationally dependent. As such, each Program Management Office must determine the most appropriate Test and Evaluation management techniques based on that program's specific needs.

Virtual Co-location: The contractor's development and planned use of a "virtual co-location" system to keep supervisory personnel and engineers in real-time or near real-time contact with test personnel in the field appears to enhance test resource optimization. Enabling engineers at the facility to observe how the system performs or fails to perform, increasing electronic data transformation, and having video recordings of actual malfunctions should enable engineers to identify short-term and long-term solutions in a more effective and efficient manner. Faster and more effective solutions should reduce the schedule risk associated with system malfunctions and test delays.

IPT Decision-Making: Those military members assigned to DRPM-AAA without previous acquisition experience had not been exposed to the IPPD/IPT process, and therefore did not initially understand the difference between the IPT decision-making process and the more traditional "staff planning process."

TEMP Update: The PMO has been successful in generating an updated TEMP because of four key decisions. First, the program convened the process as early as possible. Second, the program actively sought input from all OSD oversight agencies especially with respect to Live Fire Test and Evaluation. Third, the program worked closely with the requirements developer to ensure that the ORD update process paralleled the TEMP update process ensuring continuity between the two documents. Finally, the program maintained close and constant coordination with the independent operational test director from MCOTEA. This coordination allowed MCOTEA and the DRPM to develop Part IV of the TEMP with a significant level of continuity.

COIs: Though the new COIs address the use of the AAAV in an amphibious force supporting both the Navy-Marine Corps Team concept and the OMFTS OTH concept, the COIs do not reference the use of the AAAV in support of a Marine Air Ground Task Force (MAGTF). Inclusion of the term MAGTF in any one of the COIs would increase the level of assumed interoperability and compatibility necessary for the AAAV system in an operational environment. Inclusion of the MAGTF concept would also increase the level of understanding of the AAAV's required capabilities by those unfamiliar with the AAAV, but who are familiar with MAGTF operations.

C. RECOMMENDATIONS

1. Program Managers and Requirements Representatives should determine a system's Key Performance Parameters (KPPs) as early in the acquisition process as possible, and then aggressively defend those KPPs against "better" requirements. Stable and consistent KPPs establish the foundation for the program and its entire test effort.

2. Program Managers and Program Test Managers should review the lessons learned for applicability to other major defense acquisition programs.

3. Program Manager's should give full consideration to the benefits of the acquisition reform efforts of down selection to one contractor in the PDRR phase, co-location of the Government and the Contractor in the same facility, and implementation of the IPPD/ITP process.

4. Program Managers should emulate the DRPM-AAA's decision to develop and maintain a working relationship that "actively engages" both the oversight agencies and the external agencies early in the test planning process in order to best meet agency requirements, exploit agency knowledge and expertise, and achieve enhanced test resource efficiency.

5. Program Managers considering a co-location decision should account for the segmenting of the contractor's test capabilities by assessing the number, experience, and skill level of test personnel required for projects based on the level of system complexity.

6. Military members newly assigned to a program office should be trained to understand the differences between the IPT decision-making process and the more traditional "staff planning process."

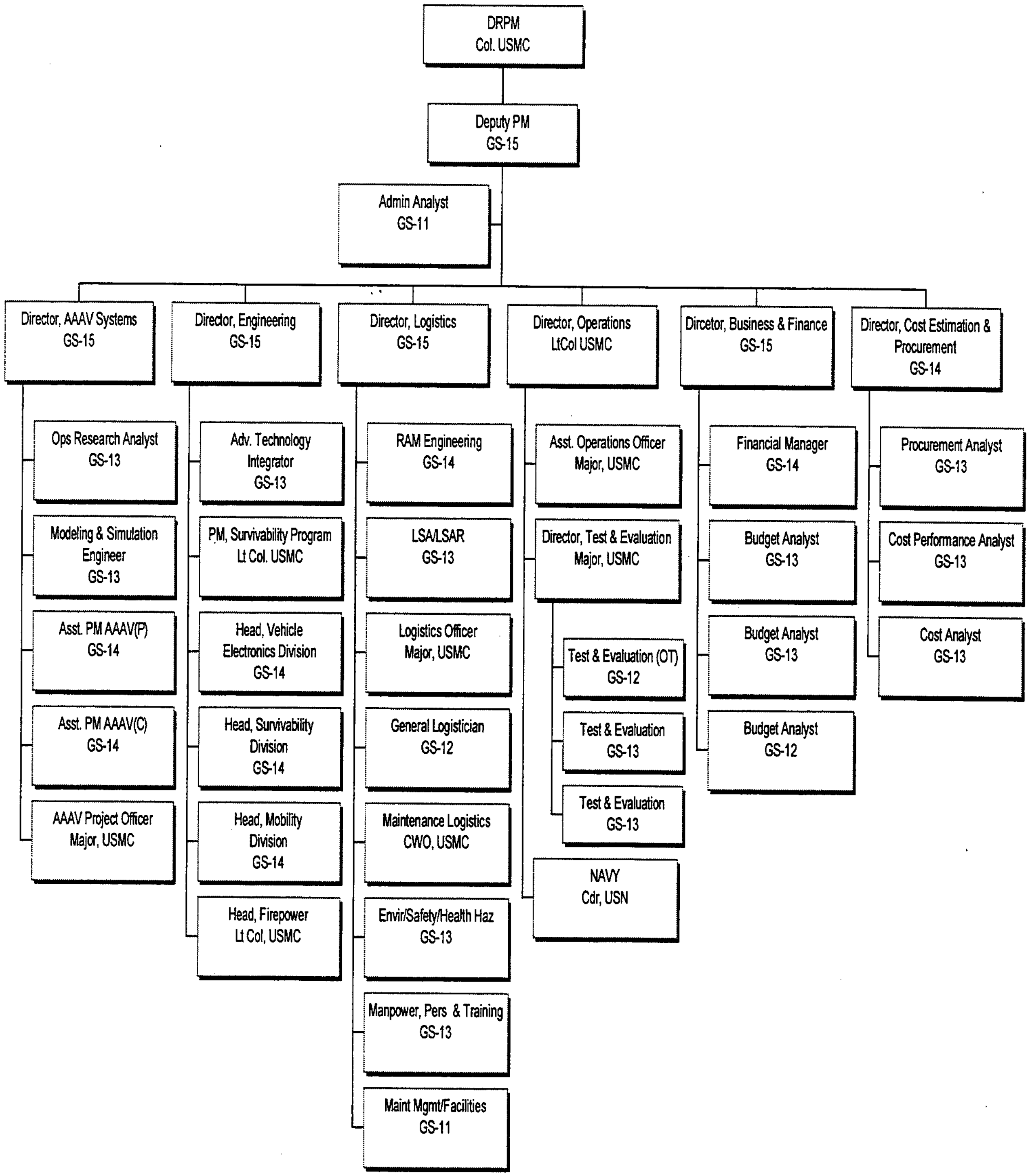
7. The term MAGTF should be included in at least one of the AAAV's COIs in order to increase the level of assumed interoperability and compatibility necessary for the AAAV system in an operational environment, and to increase the level of understanding of the AAAV's required capabilities by those familiar with MAGTF operations.

D. AREAS FOR FURTHER RESEARCH

As a result of this research effort, the author recommends the following test and evaluation questions for further research:

- What role can, or does, Modeling and Simulation play in reducing Developmental Testing, Operational Testing, and Live Fire Test and Evaluation?
- Is it justifiable to use EMD prototypes in place of LRIP articles for IOT&E, and then use LRIP articles for FOT&E?
- What are the guiding principles for integrating Developmental Testing and Operational Testing?
- How can the effectiveness and suitability of system software best be tested?
- How effective is a Model-Test-Model approach to system development?

APPENDIX A. DIRECT REPORTING PROGRAM MANAGER, ADVANCED AMPHIBIOUS ASSAULT PROGRAM ORGANIZATION



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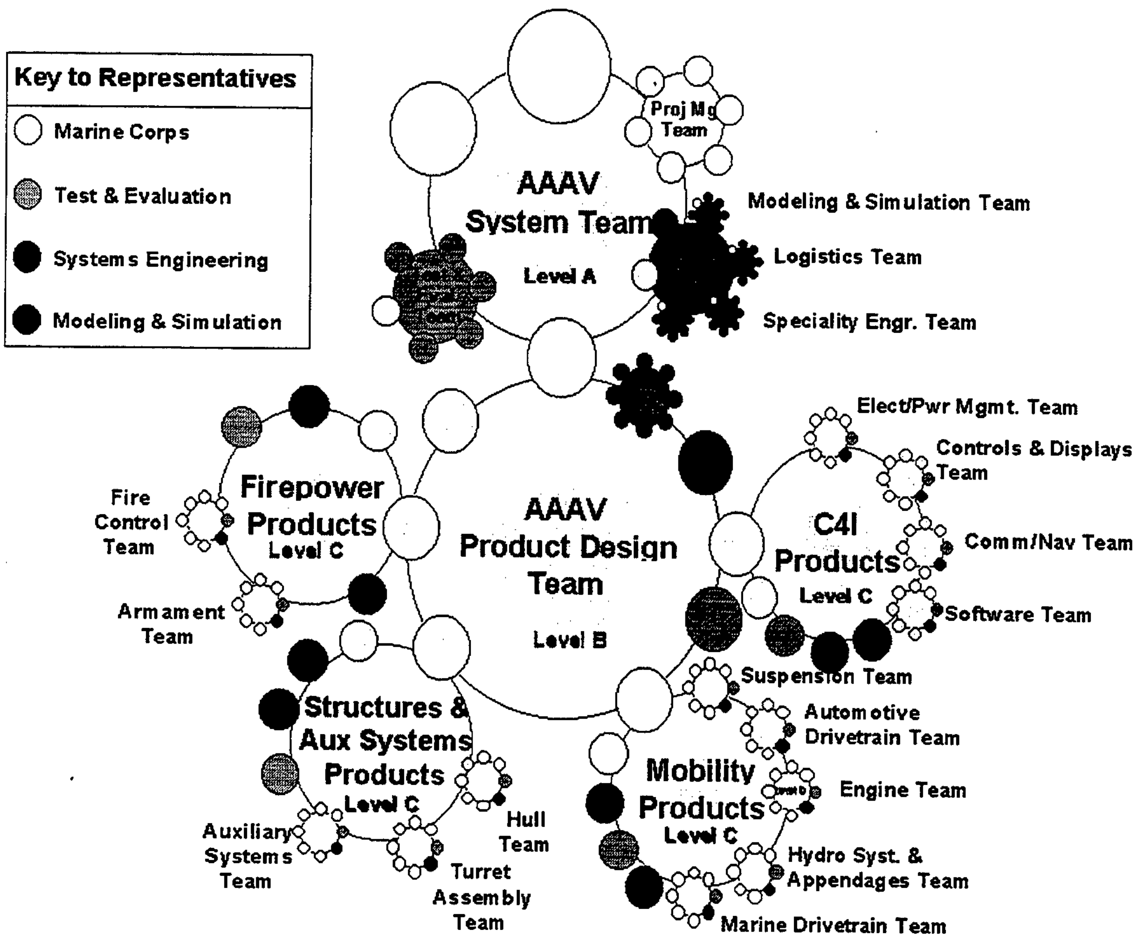
APPENDIX B. AAAV PROGRAM LEVEL INTEGRATED PRODUCT TEAMS (IPT)



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APPENDIX C. TEST AND EVALUATION RESPONSIBILITIES

The following is a list of test and evaluation responsibilities as delineated in the DRPM AAA's 1999 Draft Test and Evaluation Master Plan [Ref. 57:pp. II-2 through II-7]:

1. DIRECT REPORTING PROGRAM MANAGER AAA.

a. Coordinate all test and evaluation planning in the TEMP.

b. Plan, program and formulate budgets associated with AAAV test and evaluation. Coordinate completion of all test products required for I-IPT, O-IPT, and Milestone Reviews.

c. Update TEMP.

d. Chair the T&E WIPT.

e. Issues the Safety Assessment for all phases of testing, including presentations to the Weapon System Explosive Safety Review Board (WSESRB).

f. Chair RAM Scoring Conference for Developmental Testing. The Failure Definition and Scoring Criteria (FDSC) utilized for the AAAV test program will be adjudicated by MCOTEA, DRPM AAA and MCCDC prior to the beginning of testing.

g. Develop test issues based on thresholds established in the AAAV Operational Requirements Document.

h. Establish and execute the Developmental Test program for the AAAV.

(1) Identify and establish responsibilities for test facilities. Identify resources required to accomplish DT.

(2) Coordinate test schedules, test sites, instrumentation and data collection requirements, safety and environmental issues, training and logistical support.

(3) Conduct of DT Test Readiness Review.

(4) Develop DT&E test reports and quick-look reports.

(5) Review and approve Logistics Demonstration Plan developed by the contractor. Provide the Marine maintainers that will perform the Logistics Demonstration(s).

i. DRPM AAA will review and analyze the transportability engineering aspects of the AAAV.

j. Establish, direct, fund and execute the Live Fire Test and Evaluation program for the AAAV. Significant management responsibilities are found in Part IV.

k. Coordinate with MCOTEA for the AAAV operational test program.

(1) Establish program expectations for operational tests.

(2) Participate in any Test Integration Working Group (TIWG) established by MCOTEA.

(3) Provide training for Marine operators and maintainers selected for all OT events.

l. Provide End-of-Test Phase Report to DTSE&E and DOT&E listing the T&E results, conclusions and recommendations prior to Milestone decision and final decision to proceed beyond LRIP.

2. MARINE CORPS OPERATIONAL TEST & EVALUATION ACTIVITY (MCOTEA).

a. Establish liaison with DPRM AAA for test requirements and plans.

b. Develop Operational Test plans, schedules, and resources for the TEMP Section IV.

c. Participate on AAAV T&E WIPT.

d. Voting member of the RAM Scoring Conference. Chairs conference during OT events.

e. Concur with the TEMP.

f. Plan and conduct AAAV OT&E.

(1) Plan and chair Operational Test Readiness Reviews.

(2) Coordinate operational test schedules, sites, instrumentation and data collection.

(3) Coordinate with DPRM AAA for opportunities to integrate DT/OT events.

(4) Coordinate Fleet Marine Force users for AAAV operational test events.

(5) Chair AAAV Test Integrated Working Group (TIWG).

(6) Support the validation and accreditation of models, targets and threat simulators.

g. Provide Operational Test Independent Evaluation Reports.

h. Participate in the AAAV Live Fire Working Group. MCOTEA's responsibilities in the context of Live Fire Test support are delineated in Part IV.

3. MARINE CORPS COMBAT DEVELOPMENT COMMAND (MCCDC)

a. Develop AAAV system requirements and operational doctrine.

b. Member of the AAAV T&E WIPT.

c. Member of the RAM Scoring Conference.

d. Member of the Live Fire Working Group and the Live fire Damage Assessment Team (DAT). MCCDC shall organize, train and equip Battle Damage Assessment and Repair (BDAR) teams to perform BDAR for selected LFT events. MCCDC will validate operational loadouts in support of FUSL testing. Additionally MCCDC will provide for maintenance and repair support as required for LFT&E of the AAAV.

e. Concur with the TEMP.

4. MARINE CORPS INTELLIGENCE ACTIVITY (MCIA)

a. Serves as a voting member of the DAT and the Live Fire Working Group. MCIA provides threat assessments and definitions to the working group to aid in shotline selection for ballistic tests and to ensure that the vehicle is evaluated against realistic threats that it will be expected to see during its service life.

b. Assists the DRPM with development of the Systems Threat Analysis (STA).

5. DIRECTOR TEST, SYSTEMS ENGINEERING, AND EVALUATION (DTSE&E)

a. Approve the TEMP.

b. Observe DT&E to ensure adequacy of testing and to assess test results.

c. Provide technical assessment of DT&E conducted on AAAV.

d. Member of the AAAV T&E WIPT. May participate in other AAAV IPTs as required.

e. Reviews AAAV program documentation for DT&E implication and resource requirements to provide comments to USD(A&T) and DAB.

6. DISA JOINT INTEROPERABILITY TEST COMMAND (JITC)

a. Perform requirements analysis of AAAV program documents and updates (e.g. MNS, ORD, TEMP)

b. Support the preparation and review of AAAV documents.

c. Prepare and review detailed interoperability test procedures for AAAV Command, Control, Communications, Computers and Intelligence (C4I) systems.

d. Attend interoperability meetings, forums and conferences.

e. Prepare and maintain a C4I Interoperability Certification Evaluation Plan (ICEP).

f. Define C4I interoperability test data collection methods (DT and OT).

g. Provide test site(s), equipment and personnel resources, as required, during C4I interoperability tests.

h. Participate in C4I tests and/or review test data as basis for system certification.

i. Provide system certification recommendations for AAAV C4I interoperability.

7. DIRECTOR OPERATIONAL TEST AND EVALUATION (DOT&E)

a. Approve the TEMP.

b. Approve AAAV operational test plans.

c. Observe T&E preparation and conduct.

d. Analyze results of T&E conducted on AAAV.

e. Provide oversight of AAAV Live Fire testing (see Table IV-6 for document approval).

f. Member of the AAAV T&E WIPT.

g. Voting member of the DAT and the Live Fire Working Group.

h. Reviews and comments on the Service Vulnerability Evaluation Reports. Provides an independent vulnerability report to Congress.

i. Prepare AAAV Beyond LRIP report to submit to SECDEF and Congress.

8. ARMY EVALUATION ANALYSIS CENTER (EAC)

a. EAC will assist in the conduct and planning of the Full Up System Live Fire Test (FUSL). This includes assistance with the development of a detailed strategy for the FUSL test, assistance with evaluation of LFT&E data and assistance with preparation of the independent assessment of the vulnerability of the AAAV.

b. Voting member of the DAT and the Live Fire Working Group.

9. <u>ARMY RESEARCH LAB (ARL)</u>

a. Voting member of the Live Fire Working Group. Prepares pretest predictions for all Ballistic Hull and Turret (BH&T) and FUSL events, collects data from FUSL test events and provides a damage assessment report detailing the results of the FUSL tests.

b. Chairs the DAT.

10. <u>TEST SITES</u>

a. <u>Aberdeen Test Center (ATC), Aberdeen MD</u>

(1) Coordinate land mobility test planning, resources, and execution for DT-I.

(2) Provide safety recommendations and DT-I land mobility test report.

(3) Voting member of the DAT and the Live Fire Working Group. ATC will prepare detailed live fire test plans and conduct testing as assigned by DRPM AAA and the Live Fire Working Group.

b. <u>Amphibious Vehicle Test Branch (AVTB), Camp Pendleton CA</u>

(1) Coordinate water mobility test planning, resources and execution for DT-I.

(2) Provide recommendations and DT-I water mobility test report.

(3) Support MCOTEA in resource planning and EOA conduct.

c. <u>Eglin Air Force Base</u>

(1) Coordinate firepower test planning, resources and execution for DT-I.

(2) Provide recommendations and DT-I firepower test report.

d. Test agencies and test site locations for EMD (DT-II) have yet to be determined.

11. <u>GENERAL DYNAMICS AMPHIBIOUS MARINE SYSTEMS (GDAMS).</u>

a. Develop Detailed Test Plans for developmental testing.

b. Conduct acceptance testing for each prototype.

c. Provide maintenance and logistic support of the prototype vehicles (prior to IOT&E).

d. Transport of the prototypes from test site to test site.

e. Provide safety assessment report to support the DT Test Readiness Review.

f. Develop operator and maintenance manuals for the AAAV system to support testing.

g. Provide operators and maintainers for the prototype vehicles.

h. GDAMS will develop the training curriculum and conduct the training, under DRPM AAA supervision, for the operators and maintainers of all test vehicles.

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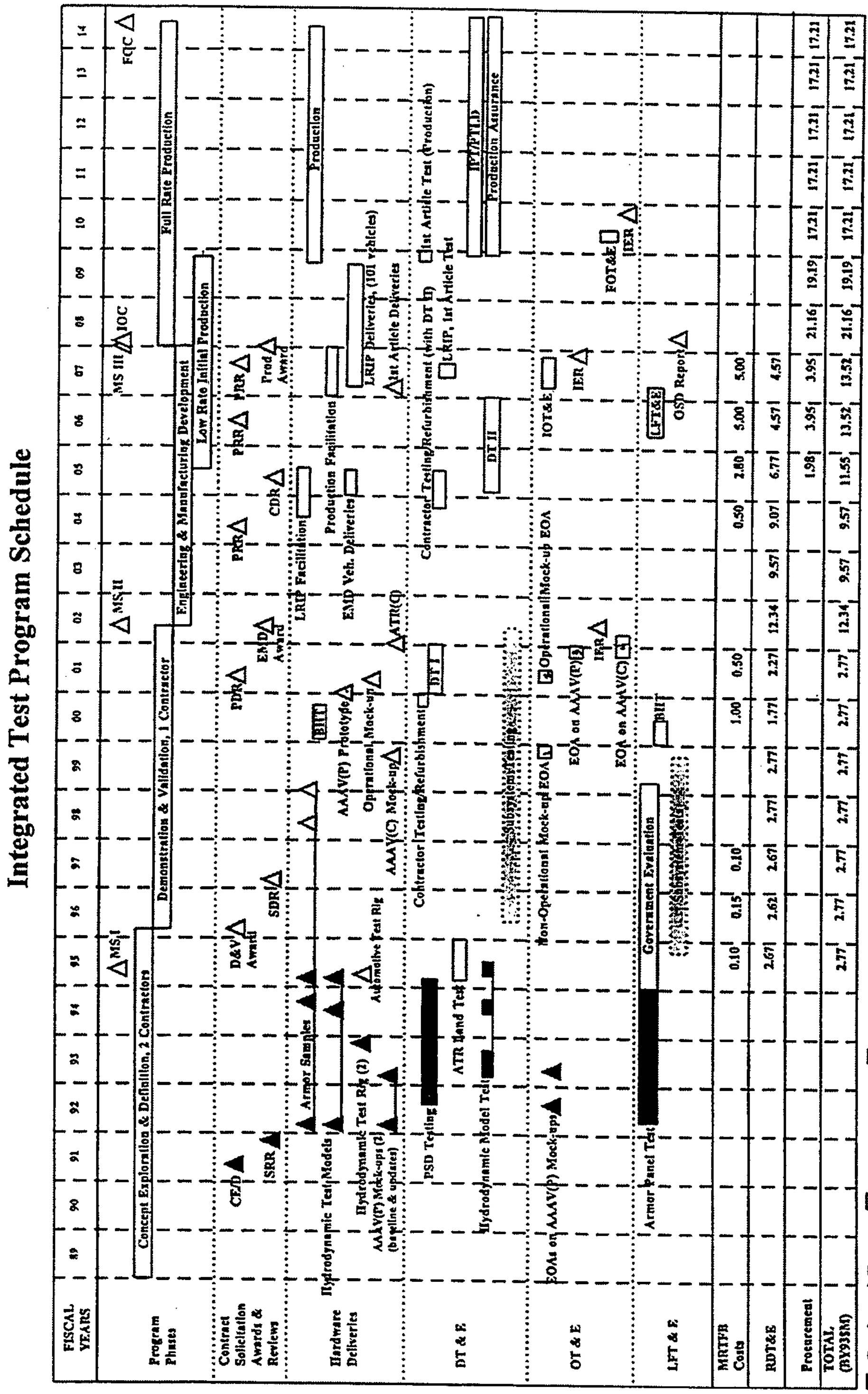
APPENDIX D. AAAV INTEGRATED TEST PROGRAM SCHEDULE - 1995 TEST AND EVALUATION MASTER PLAN



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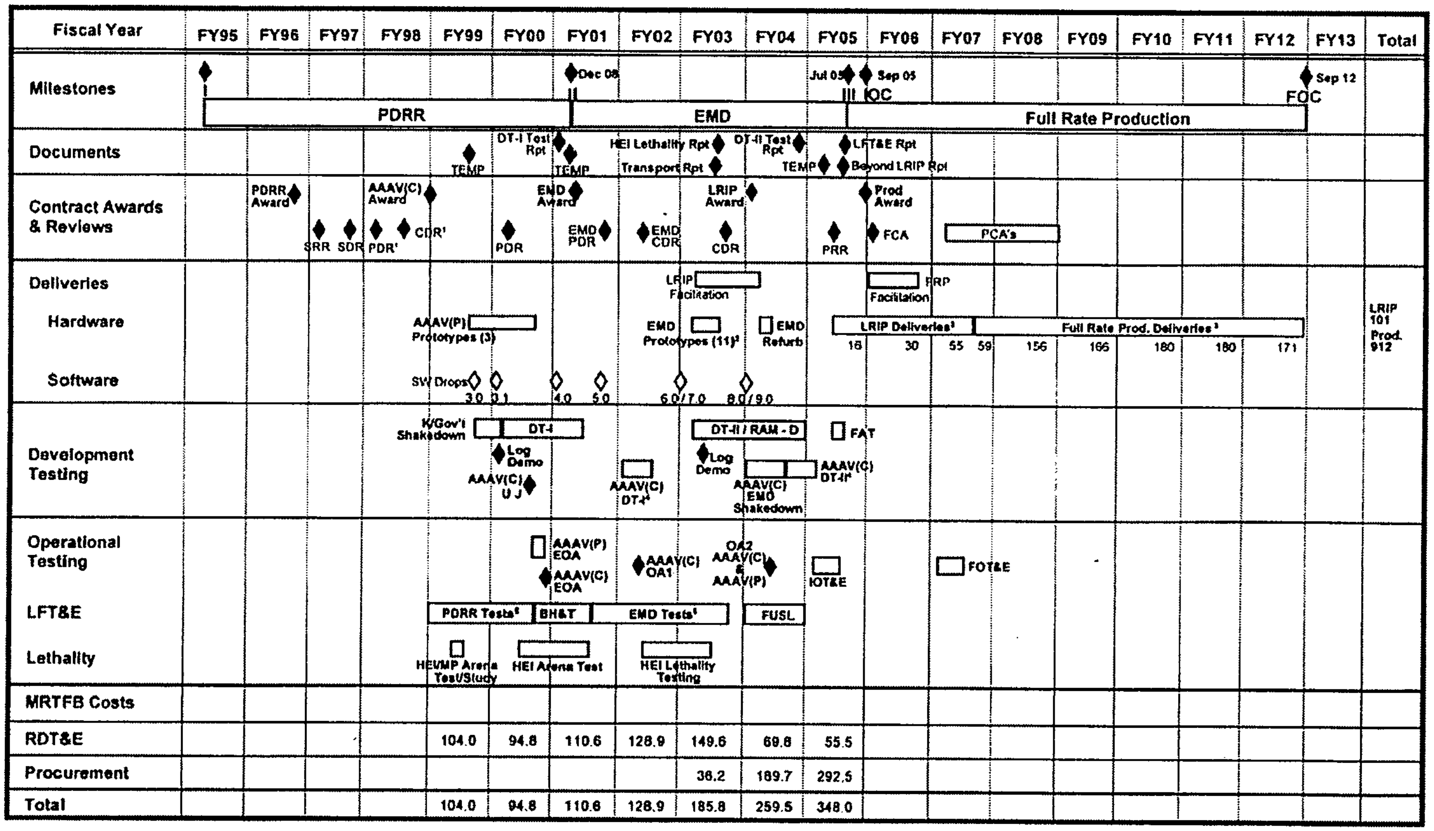
APPENDIX E. AAAV INTEGRATED TEST PROGRAM SCHEDULE - 1999 DRAFT TEST AND EVALUATION MASTER PLAN



¹ PDRR prototype vehicle PDR and CDR

² 2 EMD vehicles go to LFT&E; 9 vehicles continue RAM-D testing

³ LRIP includes 10 AAAV(C) (3 FY06, 7 FY07); Full Rate Production includes 68 AAAV(C) (7 FY07, 15 FY08, 15 FY09, 16 FY10, 15 FY11)

⁴ AAAV(C) DT-I includes a Shakedown Period, JITC Interoperability Testing and a Log Demo for those portions of the prototype unique to AAAV(C)
AAAV(C) DT-II also includes JITC Interoperability Testing

⁵ Live Fire PDRR and EMD Tests include Component Ballistic, Armor Characterization, Controlled Damage, AAAV(C) Controlled Damage and Characterization Testing

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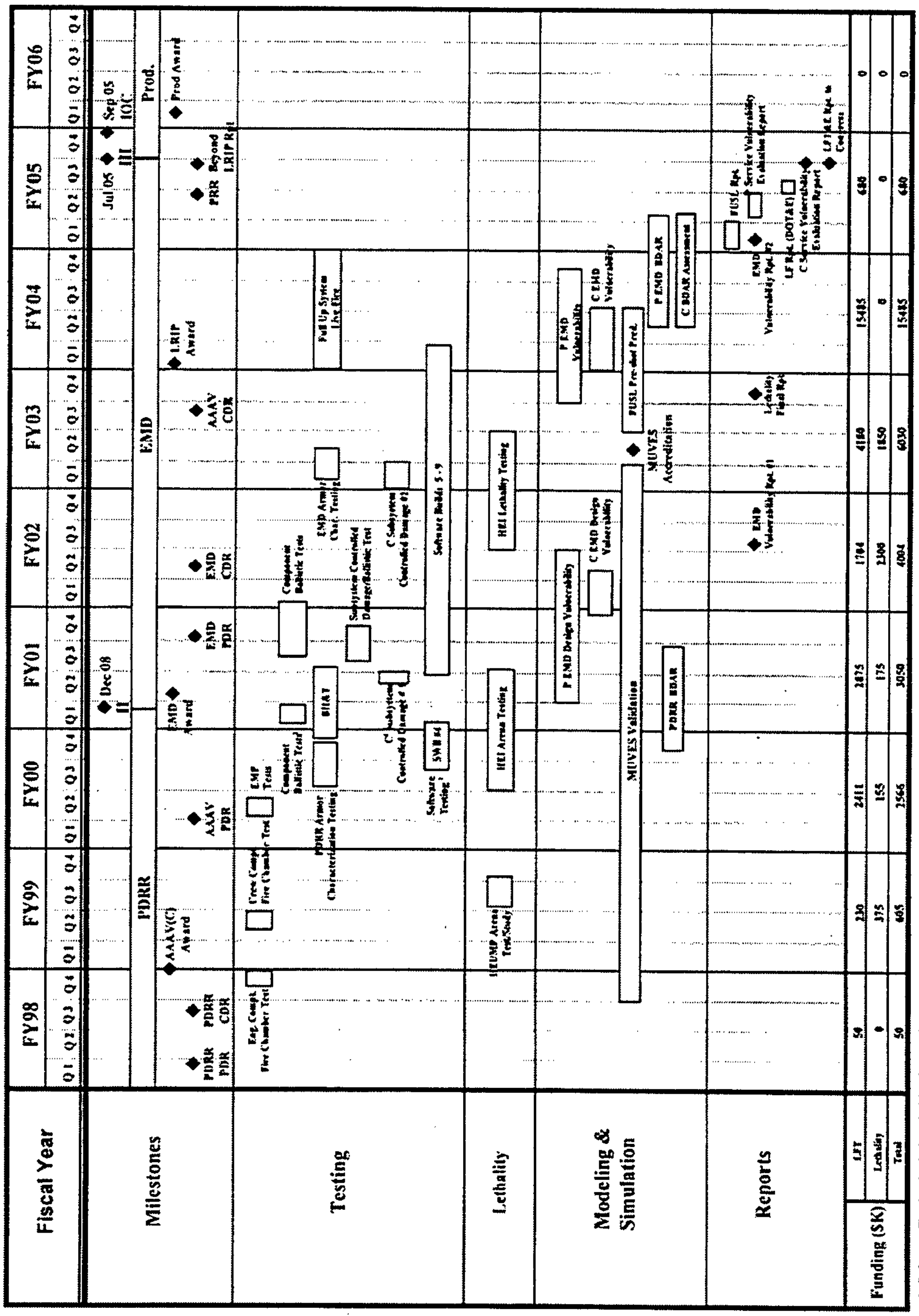
APPENDIX F. AAAV LIVE-FIRE TEST SCHEDULE - 1999 DRAFT TEST AND EVALUATION MASTER PLAN



1 Software Testing includes: Criticality Analysis, Test/Assessment Plan development, Controlled Damage Testing, Clean-up Recommendations and Test Report for each build level.
2 Some Components are planned to be tested as part of the BH&T.
3 "C" refers to AAAV(C) variant unique testing and simulation.

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APPENDIX G. AAAV COST AND OPERATIONAL EFFECTIVENESS ANALYSIS (COEA) – 1995 INTEGRATED PROGRAM SUMMARY

Alternatives Assessed and Results

a. Alternatives Considered

A total of 13 basic alternatives were evaluated during the concept phase. These alternatives fell into four general categories: Low Speed Amphibious Vehicles, High Speed Amphibious Vehicles, Non-Amphibious Vehicles, and Non-Vehicle Alternatives.

Low Speed Amphibious Vehicles operate as displacement vehicles when in the water. They are therefore limited to water speeds of approximately 6-9 knots. On land these alternatives operate as tracked Armored Personnel Carriers (APCs). While able to operate independently over short distances in the water, they must rely on LCACs for ship-to-shore maneuver. Within the category of Low Speed Amphibious Vehicles are the following specific alternatives:

- AAV7A1: The existing system.
- AAV7A2(S): A product improved AAV7A 1.
- AAAV(S): A newly designed low speed vehicle.
- Submersible: A newly designed tracked vehicle which would transit to shore below the surface of the water.

High Speed Amphibious Vehicles are self deploying and operate independently from LCACs during ship-to-shore maneuver. They are capable of water speeds far greater than a displacement vehicle. The water speed of this category of alternatives is 20 knots or greater. High Speed Amphibious Vehicles operate as armored personnel carriers on land. Within the category of High Speed Amphibious Vehicles are the following alternatives:

- AAV7A2(F): A product improvement to the existing AAV7A1 to attain high water speed.
- AAAV(F): A newly designed high water speed amphibian vehicle.

Non-Amphibious Vehicles are systems which cannot operate independently during water operations and must rely on LCACs for ship-to-shore maneuver. These systems also operate as armored personnel carriers on land. Within the category of Non-Amphibious Vehicles are the following specific alternatives:

- APC(X): A newly designed armored personnel carrier.
- LAV-25: An existing wheeled vehicle in the USMC inventory.
- M113A3: An existing APC in the U.S. Army inventory.
- M2A2: An existing Infantry Fighting Vehicle in the U.S. Army inventory.
- FIFV: A future infantry fighting vehicle which was planned for development by the U.S. Army.

Non-Vehicle Alternatives are systems which do not provide armor protected land mobility or direct fire support to Marine infantry. These systems provide only ship-to-shore transportation. The Non-Vehicle alternatives include the following:

- All Surface Option: Marine infantry carried ashore in temporary shelters aboard LCACS.
- All Air Option: Marine infantry carried ashore exclusively by helicopters.

b. Rejected Alternatives and Reasons for Their Non-selection

The alternatives were analyzed within the initial COEA in three separate areas. These areas were system performance, force effectiveness, and life-cycle cost. The performance analysis examined the capabilities of each alternative relative to Ship-To-Shore Movement, Mobility Ashore, Survivability, and Lethality. The purpose of the performance analysis was to screen the least capable systems from the group in order to concentrate the bulk of analytical resources on the more promising alternatives. The performance analysis resulted in the screening of six of the alternatives from further consideration. These alternatives were the submersible, AAV7A2(F), M2A2, FIFV, All Air and LAV-25. Both the AAV7A1 and M113A3 did extremely poorly; however, the AAV7A1 was carried forth as the baseline and M113A3 remained due to its exceptionally low cost.

The remaining alternatives were then analyzed by looking at their contribution to force capability as a whole. Two force-on-force scenarios spanning the full range of combat intensity levels were run for each of the remaining alternatives. The effectiveness analysis examined a range of Measures of Effectiveness (MOEs) including Loss Exchange Ratio (LER), force movement. percentage of the force surviving, force ratio, and time to move the Assault Element from ship to shore. Three additional alternatives were screened as a result of this analysis. These were the AAV7A1, M113A3 and the Surface Option. Finally, the four remaining alternatives were analyzed to determine life cycle costs.

As stated above, the performance analysis resulted in the screening of six of the 13 alternatives from further consideration. These were: the submersible, the AAV7A2(F), the M2A2, the FIFV, the LAV-25, and the Air Option. The submersible was screened as it was determined that this alternative offered no appreciable performance improvements, but included a significant amount of technical and operational risk associated with this new technology. Due to the restrictions imposed by the vehicle's existing hull form the AAV7A2(F) was found to be a high risk technical venture and would require nearly twice as many vehicles to carry the same number of personnel due to its reduced capacity caused by the integration of high water speed machinery. The M2A2, LAV-25 and FIFV would also require a significant number of increased vehicles and crews to carry an embarked Marine infantry unit. Their employment would also result in the requirement for additional amphibious ships and LCACs to achieve minimally acceptable force mobility and force buildup rates. Finally, the air option was screened in favor of the surface option as it provided no measurable difference when considering the delivery of Marines to beach landing sites. This, combined with the effect of no potential increases in helicopter requirements (or adverse effect of the designated helicopter delivered force) further corroborated the screening out of the Air Option.

As a result of the operational effectiveness analysis, the surface option, the M113A3, and the AAV7A1 were all screened from further consideration. These alternatives were found to be significantly less capable than the other remaining alternatives in both scenarios and for all MOEs. Of the 13 original alternatives, four remained. These were; AAV7A2(S), AAAV(F), AAAV(S), and APC(X).

c . Results of Cost and Operational Effectiveness Analysis

In every measure of effectiveness the AAAV(F)-equipped expeditionary force uniformly surpassed all other alternatives. This superiority also remained constant throughout the sensitivity analysis conducted subsequent to the operational effectiveness analysis. Given its significant contribution to force effectiveness, its uniform superiority to remaining alternatives, and its total compatibility with Marine

Corps doctrinal and tactical concepts, the AAAV(F) was selected as the service choice.

In 1993 an update to the original COEA was conducted. This analysis evaluated several different development and acquisition strategies but did not introduce new system alternatives. In the updated COEA the baseline system is referred to as the AAV7A1E2. It is identical to the original baseline system (AAV7A1) with some postulated changes to the vehicle suspension system. Its overall capability remained the same as evaluated in the original COEA. In essence, the updated COEA looked at four high-low mixes of previously existing alternatives and their associated costs. All four mixed fleet alternatives included a number of high speed amphibians (AAAV(F)) to conduct amphibious operations. The analysis also looked at several different development approaches to obtain mixes of previous alternatives. As such, the results of the effectiveness analysis portion of the original COEA did not change. The four "new" alternatives evaluated are described as follows:

AAAV(FO): This mixed fleet alternative included high speed amphibians (AAAV(F)) for amphibious operations and the current or baseline system (AAV7A1E2) used for the remainder of the Marine Corps' mobility requirements (ex: Maritime Prepositioned Ships).

AAAV(FO+): This alternative is identical to the one previously described except that an upgraded weapon station identical to the AAAV(F) has been installed in the baseline system.

AAAV(M): This alternative, from an operational effectiveness point of view, is a high-low mix of the original AAAV(F) and AAAV(S). An important feature of this alternative is the development strategy, in that the AAAV(M) is a new design and modular in configuration. This would permit the conversion of the high water speed amphibian to a slow water speed amphibian (or vice versa) at the Depot maintenance level.

AAAV(V): This alternative results in the same capability as the AAAV(M); however, it is achieved through a series of five major block improvements over a 20+ year period. The AAAV(V) begins with several block changes to the baseline system and ends with an entirely new vehicle capable of conversion from high water speed to low water speed configurations (or vice versa).

The results of the updated COEA, while providing several assumption based options, did not come to definitive conclusions. The Marine Corps' evaluation of the results is as follows:

AAAV(FO): While providing, the most operationally effective alternative for a portion of the force, this alternative was rejected for a number of significant reasons. First, the baseline system in this mixed fleet option, which would represent the majority of the mobility assets for the Marine Corps, is an alternative which has consistently demonstrated complete operational ineffectiveness and is obsolete by definition. Second, the introduction of two vastly different systems into the inventory would dramatically compound training, supply, personnel, maintenance, deployment and operational suitability problems.

AAAV(FO+): Again, while providing the best alternative for a portion of the force it was rejected for the same reasons as the AAAV(FO). In addition, this alternative raises technical concerns in that the integration of a weapon station with similar capabilities as other alternatives would seriously deplete the reserve buoyancy of the existing vehicle during water operations (safety). It would negatively affect the vehicle's vertical and longitudinal centers of gravity (posing stability problems during water operations), add significant weight to a vehicle whose suspension system and final drives are already overtaxed from the addition of existing product improvements, and cause a decrease in the infantry carrying capacity of the vehicle due to the added internal volume of the turret basket.

AAAV(M): The principal negative attribute of this alternative is the suboptimization of the system design caused by the requirement to have it easily convertible from one amphibious configuration of the vehicle to another. There is also an added technical complexity factor for a design which must be as dramatically flexible as this alternative requires. A mixed fleet of newly designed high and low water speed amphibious vehicles that share many identical systems and attributes will not have nearly the impact on logistics, maintenance, supply, manpower, training, and operational suitability as AAAV(FO) or (FO+). Some impacts in these areas will remain, however, and are negative factors.

AAAV(V): This alternative was strongly rejected due to the numerous areas of risk it presented. The configuration management risk present with this developmental approach was evaluated as being exceptionally high. For not less than 20 years this system would be found in multiple configurations in the operating forces posing training, logistics, maintenance and operational problems that would be devastating to operational unit readiness. In addition, the required levels of concurrence of developmental activities and testing also were considered high risk. This approach was judged to be highly susceptible to single event failure and overall program vulnerability.

d. Assessment of Cooperative Development Program

The Marine Corps is the single developer and producer of fully amphibious combat vehicles in the free world. Consequently, there are no other known or planned development or production projects, nor are there any ongoing projects which could be modified to satisfy AAAV program requirements. An assessment of the potential for cooperative development of the AAAV system has been performed resulting in the identification of specific advantages and disadvantages to cooperative development. The advantages are: (1) costs would be reduced as a result of cost-sharing with allies; (2) U.S. - allied Standardization and Interoperability (S&I) would be enhanced through the use of common systems, subsystems, assemblies, components and piece parts; (3) valuable defense-related technology could be shared reciprocally; (4) it could potentially be the impetus for broad modernization of allied amphibious forces. The disadvantage is that the uncertain economic and political position of nearly all potentially viable countries introduces a significant and unacceptable element of risk which could adversely impact both the development and production of AAAVs. However, Foreign Military Sales (FMS) does offer a viable alternative to a Cooperative Development Program that would retain the advantages of improved allied nation capability, reduced production cost, and enhanced S&I, all at minimal risk. Annex G [of the Integrated Program Summary] identifies 10 allied nations that may be interested and could benefit from AAAV Program FMS. The AAAV Program Office will explore this alternative in place of a Cooperative Development Program.

Most Promising Alternative and Rationale

The AAAV(F) is the most promising and operationally effective alternative evaluated. Its inherent characteristics provide an amphibious force with the ability to use speed as a weapon; through the rapid concentration of its available combat power at a decisive place and time. Other alternatives do not provide the velocity of combat power that an amphibious force equipped with AAAV(F) does. All other alternatives have force concentration rates over time and distance that are significantly slower, and thus inhibit our ability to seize the initiative and dictate the terms of combat by forcing the enemy to react to us. Without this initiative an amphibious force's survivability and security is greatly diminished, along with the loss of essential elements that enable maneuver and surprise. Alternatives other than AAAV(F) tend to move the amphibious force in the direction of an attrition style of warfare instead of in the direction of maneuver warfare, which is the doctrinal foundation for all U.S. Marine Corps operations. AAAV(F) is the most promising alternative from an operational perspective in that it is the most effective in achieving military objectives at the least cost in personnel and equipment.

As outlined above, the speed at which a force is able to be concentrated and maneuvered over sea and land is a determining factor for battlefield success. Of all the vehicular alternatives the AAAV(F) maneuvered the force ashore and inland faster than any other when the number of LCACs were fixed (as they presently are). The surface and air options were comparable to AAAV(F) in this area, however, they provide no mobility once ashore, nor do they afford any armor protection or direct fire support. Compared to AAAV(F) other vehicular alternatives took between 50% and 300% longer to build up a comparable level of combat power ashore. To redress this significant imbalance in critical effectiveness other vehicular alternatives would require the acquisition of additional LCACs and very costly amphibious ships and crews.

The seamlessness in which the AAAV(F) can maneuver a force versus the other alternatives pays continuing dividends in the battle ashore. In critical areas such as force movement within a theater of operations, the ratio of enemy forces lost to friendly forces lost, and at the end of combat operations, the percent of friendly forces surviving, the AAAV(F) was again superior to all others. These attributes remained and in some cases increased when AAAV(F) was subjected to the realities of combat operations via the analytical technique of sensitivity analysis. Alternatives were evaluated in situations where enemy arrival time to landing sites was faster than expected; due to the success of enemy deception or the availability of less than perfect intelligence. Other alternatives paid a consistently heavy price when this event occurred, however, AAAV(F) actually improved in the categories of loss-exchange ratio and force ratio. The decrease in total force movement using AAAV(F)'s in this situation was virtually nonexistent (less than .5 percent).

There are a number of other significant reasons why AAAV(F) is the most promising alternative. First, it is an inherently flexible and multipurpose weapon which can achieve its full military worth without the need for auxiliary craft or support equipment. All other technically feasible vehicular alternatives require that their delivery ashore be supported by naval landing craft. These vulnerable, high value transport systems are the only conveyance by which the landing forces' heaviest equipment can be brought ashore. They are dependent upon amphibious ships for their support and their loss through military action or maintenance casualty will significantly degrade force effectiveness ashore during its most critical stage. Vehicular alternatives other than AAAV(F) require these landing craft be placed in the first (and all subsequent) assault waves; lending greater probability that their vulnerability to virtually all infantry weapons will be exploited. The AAAV(F) significantly reduces the exposure of these high value landing craft to enemy action as they do not require their use as a conveyance ashore, and exceed their surf transit capability thus opening up greater littoral space for follow-on landing sites. In addition, a landing force equipped with AAAV(F) is able to organically conduct long distance shore-to-shore and riverine operations without the burden of a significant land based landing craft support structure, or the dedication of amphibious ship support at sea. The tempo of operations for a force equipped with AAAV(F) is undiminished when confronted by water barriers that previously required deliberate negotiation and the use of auxiliary equipment (i.e., landing craft, bridges, barges). Water obstacles abound along the littorals of the world and can be, for the first time, exploited as high speed avenues of approach, rather than being viewed as physical barriers which inhibit operational tempo and overall speed of maneuver. The inherent capability of AAAV(F) as both a high water speed amphibious vehicle and armored personnel carrier significantly contributed to its assessment as the most promising alternative.

As a land combat vehicle AAAV(F) has a significant advantage over all other existing, alternative systems in terms of design architecture. Its "open architecture" and partitioned design have allowed for significant growth or complete change-out of subsystems prone to rapid evolution (software, weapon system) or those that represent critical risk (propulsion system). More than just design margin or excess capacity, this open architecture and partitioned design philosophy will allow for greater evolution of the total system, over a longer vehicular life span, and at less cost per incident of vehicle change. No other existing combat vehicle possesses an inherent system architecture which promotes evolutionary growth to the level of the AAAV(F). As such, this is viewed as additional justification for its selection as the most promising alternative.

APPENDIX H. AAAV SYSTEM DESCRIPTION - 1999 DRAFT TEST AND EVALUATION MASTER PLAN

SYSTEM DESCRIPTION

1. Overview: The family of vehicles will consist of a personnel variant--AAAV(P), and a command and control variant, --AAAV(C).The AAAV Program will include vehicles and vehicle sub-systems capable of delivering the ground combat element of Marine assault forces from amphibious shipping located over-the-horizon to inland objectives. The AAAV will be a tracked-amphibious vehicle possessing both land and water mobility. The AAAV is designed to have an endurance of 250 miles after a high-speed water march of 25 NM. The estimated weight of the AAAV is 38 tons and it will measure approximately 30 ft.(L) x 12 ft.(W) x 10 ft.(H). The AAAV(P) vehicle will be operated/maintained by a crew of 3 Marines and have a troop capacity of at least 17 Marines. The AAAV(C) vehicle will retain the armored hull, land and water propulsion systems and survivability features of the AAAV(P). The communication suite for the AAAV(C) will be capable of supporting an infantry battalion or regimental commander and selected staff. The AAAV system will be comprised of a variety of sub-systems that will allow the vehicle to perform its required operational mission. The major sub-systems are the armored hull; land propulsion system; water propulsion system; command & control and weapons systems.

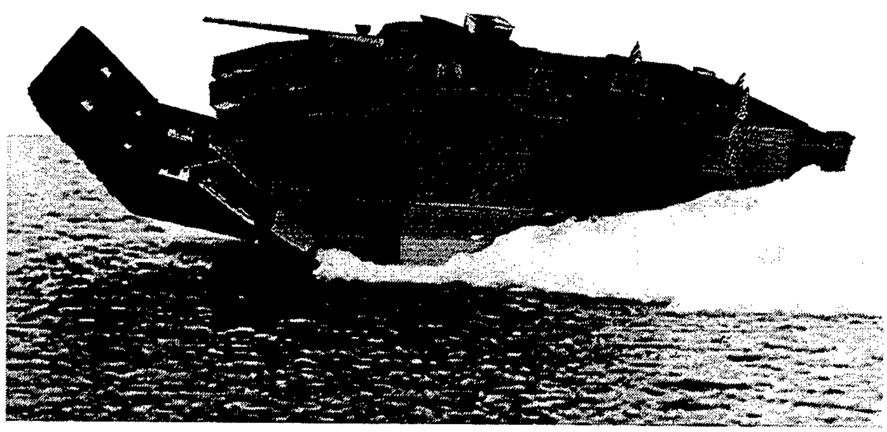

Figure H-1. AAAV(P) Representation.

2. Major Subsystems:

a. Armored Hull: The armored hull of the vehicle will be designed to provide multi-hit protection against small arms fire up to 14.5mm AP at 300 meters. The hull will also protect against artillery fragments (up to 155mm) at 15 meters from any aspect. The bottom of the hull will protect against anti-personnel mines. See Figure H-2.

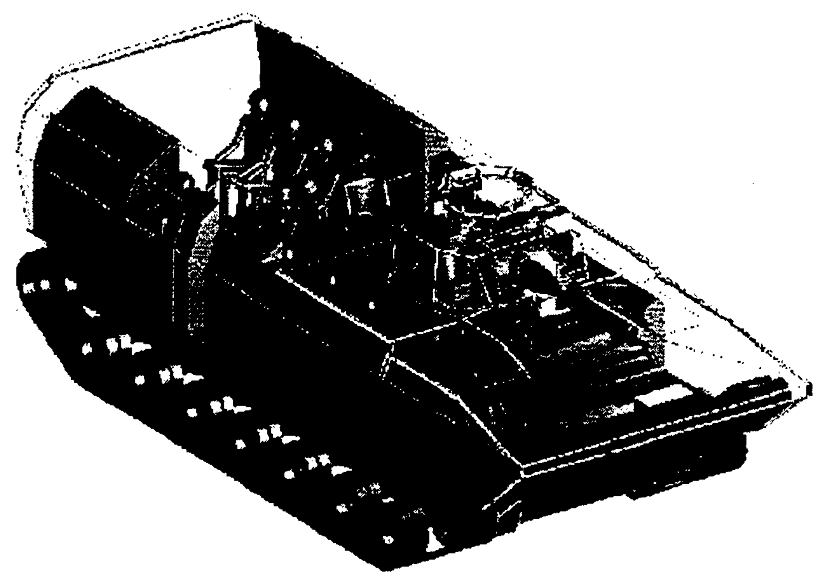

Figure H-2. "Cut Away" View of AAAV.

b. Land Propulsion: While on land, the vehicle will have the mobility capabilities to operate with USMC Main Battle Tanks. The AAAV will have the capability to traverse the same terrain at the same speed as the tank during cross-country operations without crew or troop fatigue. The AAAV will also cross all obstacles/terrain features as the tank (trench, hills, gaps, walls, soft soil, marsh, etc.). The track system will operate in conjunction with the water propulsion system in a transition mode (low water speed) to facilitate crossing the surf zone and fording rivers. See Figure H-3.

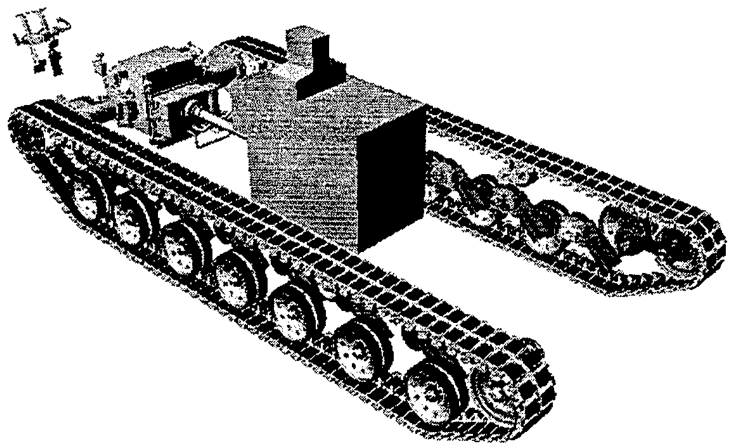

Figure H- 3. Land Propulsion.

c. Water Propulsion. The AAAV is powered through the water by two water jets (see Figure H-4). While in the water and travelling at high speed, the AAAV will be a planing hull craft. To attain this high speed, the AAAV will re-configure its external profile. This will be done through retraction of the track and suspension systems, deploying cover plates on the underside of the vehicle and extending bow and transom flaps to present a smooth surface. Steering is provided by movable steering buckets. In the water the AAAV will be able to travel at 20 knots (minimum) in Sea State III (3 foot significant wave height). At low speed, in preparation to traverse the surf zone, the flaps are retracted and the suspension is lowered and engaged to operate in tandem with the waterjet.

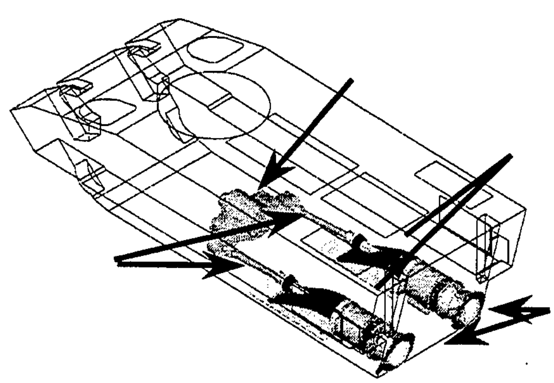

Figure H-4. Water Propulsion.

d. Command and Control. The AAAV is required to function within the Marine Corps command and control architecture and interface and inter-operate, as required, with the current and planned Joint command and control architecture. The AAAV(P), as a integral maneuver support element, will have a radio suite that will provide line of sight (LOS) and beyond line of sight communications (BLOS) capability to ensure connectivity with both higher, adjacent and subordinate maneuver/command elements. The AAAV will also possess an intercom system for communication between crew stations and the embarked infantry commander. The AAAV(C) will have an integrated C4I Suite to function as either a battalion or regimental tactical echelon headquarters. The suite will be composed of LOS and BLOS radio equipment, computer hardware, and tactical software applications. This C4I Suite will provide the embarked commander and his staff as the tactical echelon headquarters the capability to communicate with and to inter-operate with both USMC and Joint senior, adjacent, and subordinate maneuver units; combat support units; and, combat service support units. Additional detail on the interoperability requirements for the C4I suite for the AAAV may be found in the C4ISP. A functional interpretation of the PDRR version of the AAAV(C) C4I suite is pictured in Figure H-5.

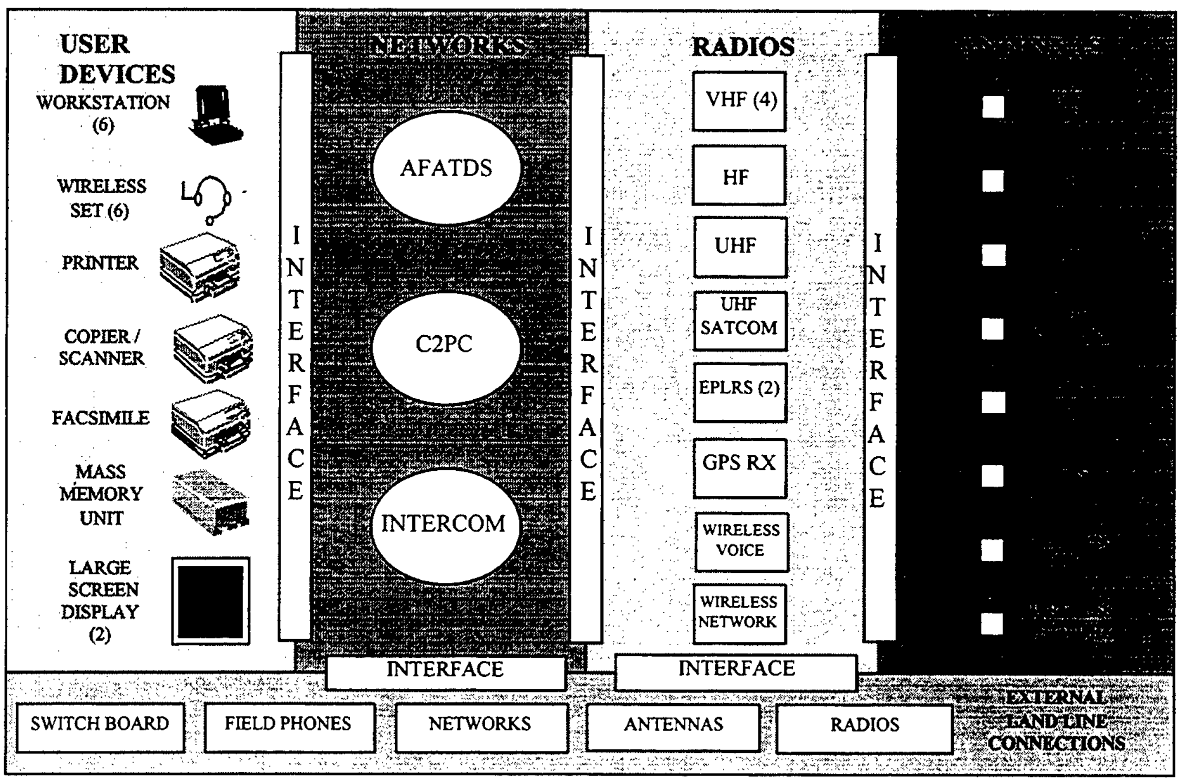

Figure H-5. AAAV(C) PDRR C4I Suite.

e. Firepower. The Mk 46 Weapon System comprises the 30mm Mk 44 Bushmaster II gun with a fully stabilized turret, Forward Looking Infrared (FLIR) optics and full solution fire control system (see Figure H-6). A coaxial machine gun will also be fitted to the turret. The AAAV(C)'s main armament will be a 7.62mm or equivalent machine gun to provide close in, self-defense capability against dismounted infantry. The AAAV weapon suite will be fully operational during vehicle operations on the land and in the water.

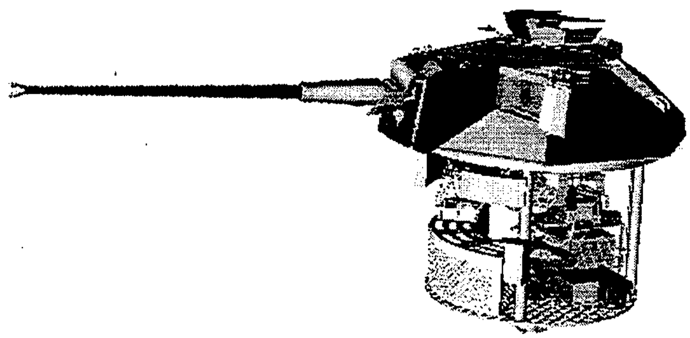

Figure H-6. 30mm Mk 46 Weapon System.

3. Software / Hardware Architecture. The AAAV vetronics system architecture is comprised of processors, controls, displays and software to provide the interface for vehicle functions that are controlled electronically. A schematic of this vetronics architecture is presented in Figure H-7. The principle components in the vetronics architecture include the following:

- Hull electronics unit (HEU)
- Turret electronics unit (TEU)
- Weapons station electronics unit (WSEU)
- Command and control server (CCS)
- Mass memory unit (MMU)
- Slip ring
- Embedded training server
- Engine and transmission controllers
- Hull power distribution unit (HPDU)
- Remote acquisition and control modules (RACM) for signal/power distribution
- FDDI, Utility, and CAN interface and data buses
- Displays and controls for each crew station

The AAAV computer software configuration items (CSCI) and their principle functions are defined as follows (additional detail may be found in the Computer Resources Life-Cycle Management Plan (CRLCMP)):

a. Controls and Displays CSCI. The Controls and Displays CSCI provides the software required for the interface between the Marine and the AAAV vehicle. Functions of the CD CSCI include mode control, fault management, menu management, diagnostics, and Marine/Machine interface control.

b. Navigational/Situational Awareness CSCI. This CSCI provides the software to support map displays, route planning, overlays, situational awareness, and reporting.

c. Fire Control CSCI. The FC CSCI software provides the fire control functionality for the AAAV weapons system. Functions of this CSCI include ballistics solutions, weapon control, stabilization, sight controller, motor controller, and fire control diagnostics.

d. Mobility/Power Management and Auxiliaries CSCI. The MPA CSCI software provides the capability for control of the primary mobility, power, and auxiliary systems to include engine, suspension, hydraulics, drive train, electric and auxiliary power, hydrodynamic appendages, bilge, NBC, environmental control, and automatic fire suppression.

e. Embedded Training/IETM. This CSCI provides embedded training for the crew positions and integrates the IETMs with the diagnostics system. The Embedded Training Server provides the interface between the PCD systems and various remote and appended simulation and training devices, thus permitting the AAAV crewmember(s) to train within the vehicle or allowing a group of vehicles to conduct joint training exercises from proximal stationary locations. The AAAV incorporates Embedded Training (ET) capable of providing simulation-based training in equipment operation, precision gunnery and navigation, and full-mission rehearsal.

The IETM provides embedded electronic technical manuals to the crew through the vehicle's controls and displays. The IETMs are integrated with the diagnostics system to provide the operator a more efficient means of accessing pertinent information.

An example of the software and hardware functional architecture is shown in Figure H-7.

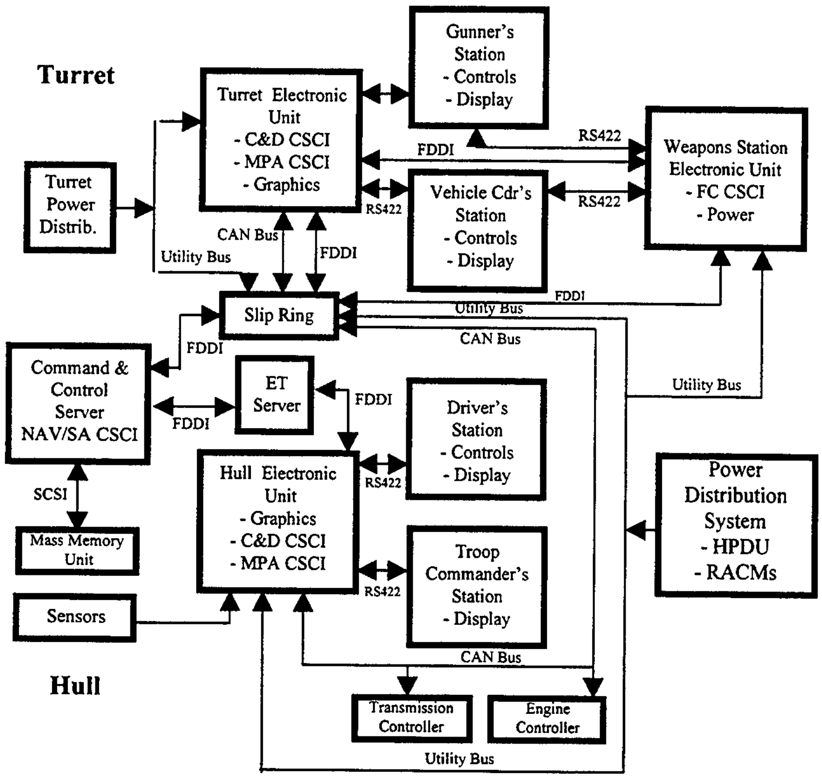

Figure H- 7. Hull and Turret Software/Hardware Functional Architecture.

f. Software Build Descriptions: The schedule for software build deliveries is shown in Table II-1 of the TEMP.

(1) Build 3.0 - provides updates and/or initial release of software to control displays, mobility for land and water, fire control, hatches and ramp, communications, navigation, fault management & self test and reporting. Builds 1.0 and 2.0 provided subsystem controls of engine, power systems and displays and were installed in the Software Integration Lab(SIL) and P1 for rollout.

(2) Build 3.1 - updates displays, fault management & self test, navigation and reporting. Provides initial release of BIT, FIT, Prognostics, Diagnostics and IETM browser. The fidelity of the ITEMs for this build is expected to be Level IV.

(3) Build 4.0 - updates software for deficiencies identified during Developmental Testing.

(4) Build 5.0 - initial release of C4I integration for AAAV(C) DT Prototype.

(5) Builds 6.0/7.0 - initial release of EMD software for the AAAV(P) and AAAV(C). Level V IETMs will be introduced with this build.

(6) Builds 8.0/9.0 - updates software for deficiencies identified during EMD DT.

4. Interfaces. Physical interfaces for the AAAV require that it must be compatible with amphibious shipping, land, rail and air transport. Operationally, the AAAV must be capable of communicating with aviation, naval and ground forces, as well as maneuvering with ground combat elements once ashore. The AAAVs will work in unison with other USMC and United States Navy (USN) assets, particularly the USMC vertical assault element (CH-53/CH-46, V-22), other surface landing craft (LCAC), and Joint service operations. The AAAV must be supportable and maintainable within the capabilities of the Marine Corps force structure. Both the AAAV(P) and AAAV(C) variants shall have similar water and land mobility characteristics. The AAAV (C) primary interfaces, to include interoperability (as specified in the AAAV C4ISP), require that it be capable of communicating and interoperating with current and planned Joint and Marine Corps aviation, naval and ground force C2 systems.

5. Survivability. Figure H-8 below depicts the potential array of methods available to the AAAV to maximize the survivability of the vehicle and its occupants. The AAAV program intends to maximize the use of most of the methods as the design matures. Recent survivability studies of combat vehicles will be examined for applicability to the AAAV.

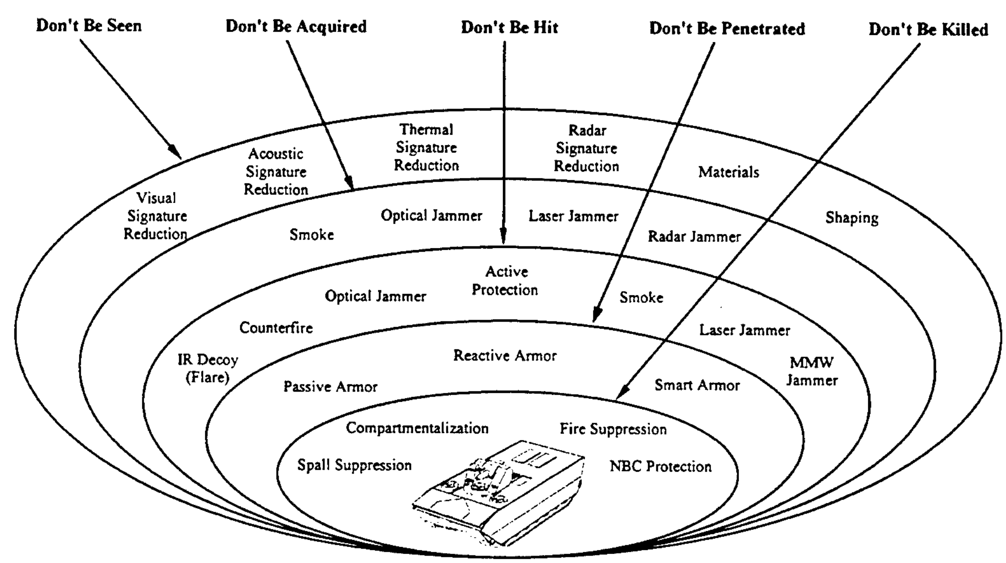

Figure H-8. Survivability Methods.

a. Susceptibility Reduction. The AAAV will use camouflage paint, low-smoke powder and flash-suppression to reduce the visual signature of the vehicle. Vehicle shape will be modified consistent with mobility and transport requirements to minimize the visual silhouette. Ceramic tiles will be used to reduce the vehicle's IR signature where appropriate. The vehicle will have a Rapid Obscuration System (ROS) using expendable smoke grenades that provide a quick and relatively thick layer of smoke around the vehicle to provide visual, IR, and/or MMW protection.

b. Nuclear, Biological and Chemical Protection. The AAAV specification requires that the vehicle be Nuclear, Biological and Chemical survivable and will be equipped with an NBC Collective Protection (CP) system and employ a NBC filtration system integrated with an Environmental Control System . The NBC CP system is designed to minimize the infiltration of NBC contaminants during open hatch operations, resupply and disembarkation/embarkation of crew/infantry. The NBC detection and warning system (NBC DW) will provide both interior and exterior point detection of nuclear and chemical contamination. Figure H-9 depicts the NBC system and Figure H-10 depicts the AAAV's NBC Protection and Environmental Control System Inlet.

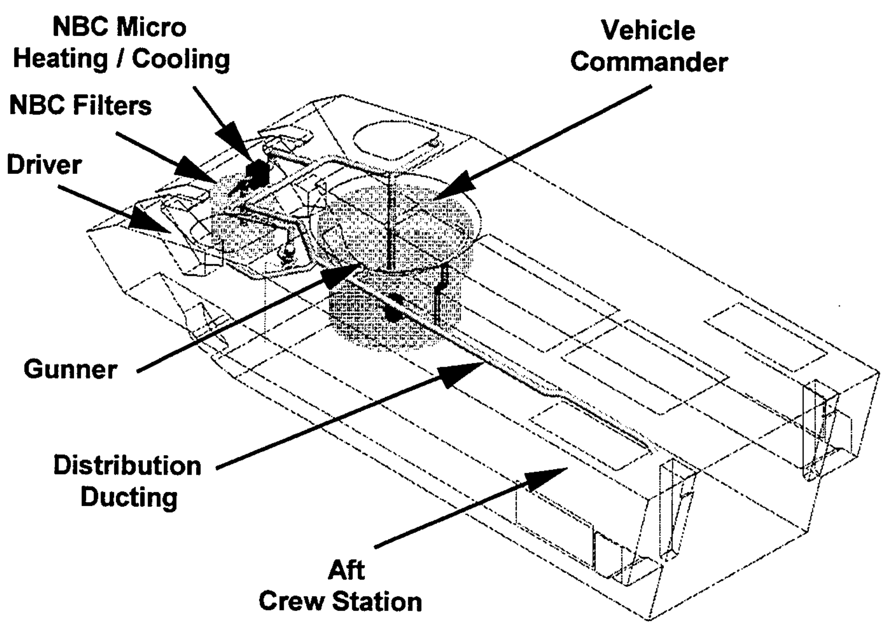

Figure H-9. NBC Protection System Integrated into the AAAV.

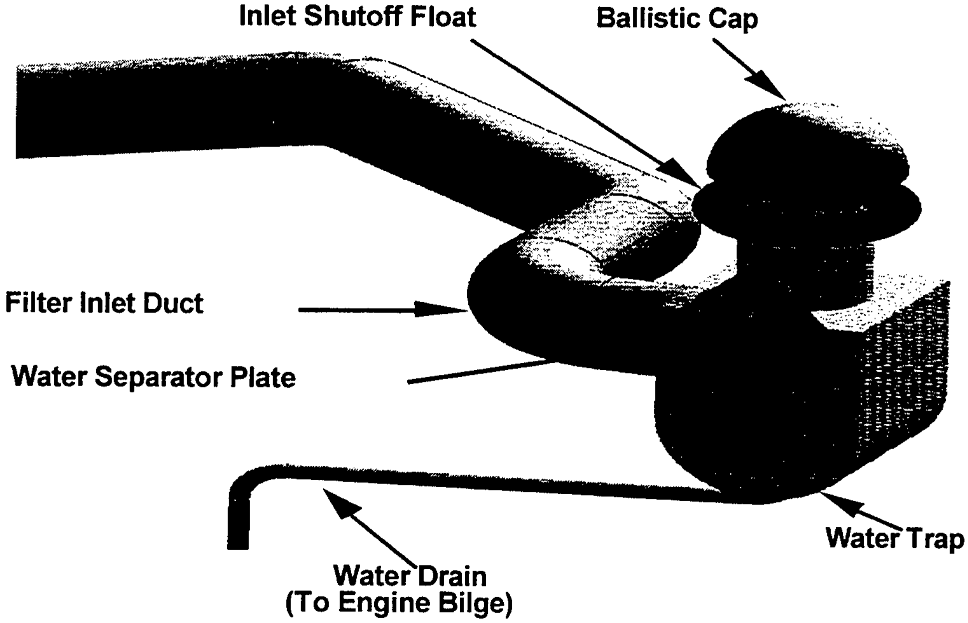

Figure H-10. NBC Protection and Environmental Control System Inlet.

6. Logistics. The maintenance concept for the AAAV program is to "fix as far forward as possible" with the intent of driving maintenance costs down while increasing the availability (or return-to-readiness) of the vehicle. On a fleet average basis of 600 engine operating hours or 6 years of service life, the AAAV will be scheduled for depot level maintenance. Maintenance of the AAAV will be conducted under a Two Level Maintenance Concept. Preventive maintenance and corrective maintenance will be accomplished at the lowest appropriate level depending upon the nature of the corrective action required. Education and maintenance will be enhanced through extensive use of IETMs to support embedded training and diagnostics. Replacement of failed or worn components will be accomplished on a piece-part basis at the appropriate level depending upon the requirements for special tools, special procedures, or special skills necessary to accomplish the required corrective action.

APPENDIX I. AAAV CRITICAL TECHNICAL PARAMETERS - 1999 DRAFT TEST AND EVALUATION MASTER PLAN

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
SURVIVABILITY						
Defeat 14.5 mm, Soviet, AP ORD para. 4.c.(1)(b)	CE DT-I DT-I	85%P_{NP} @ 300m 90%P_{NP} @ 300m 95%P_{NP} @ 300m	ATC & Ktr ATC & Ktr ATC & Ktr	FY91-93 FY00 FY00	Milestone I Milestone II Milestone II	85%
Defeat Artillery Fragments 155mm US / 152mm Soviet at 15 meters (50-feet) in a hemispherical burst pattern from vehicle ORD para. 4.c.(1)(b)	DT-I DT-II	95%P_{NP} 99%P_{NP}	ATC ATC	FY00 FY01-02	Milestone II Milestone III	
Defeat US/Soviet anti-personnel land mines* ORD para. 4.c.(1)(c)	DT-I DT-I	90% P_{NP} 99% P_{NP}	ATC & Ktr ATC	FY00 FY00	Milestone II Milestone II	
Automatic Fire Sensing & Suppression System (engine/crew/troop compartment) ORD para. 4.c.(1)(f)	DT-I	Internal fire is suppressed prior to personnel casualties	ATC ATC	FY98 FY99	Milestone II Milestone II	
Nuclear, Biological, & Chemical Survivability ORD para. 4.c.(1)(d)	DT-I DT-I	NOTE 1	ATC ATC	FY01 FY03-05	Milestone II Milestone III	
Projecting obscuration ORD para. 4.(c)(1)	DT-I DT-II	NOTE 2	ATC ATC	FY00 FY03-05	Milestone II Milestone III	
Silent watch with sufficient power for optics, communication, navigation weapon system operation, NBC detection/alarm. ORD para. 4.(c)(3)	DT-I DT-II	Independent of main engine	ATC ATC	FY00 FY03-05	Milestone II Milestone III	

*Tests done on armor sample plates, vice vehicles. Full armor tests are classified. Refer to Appendix A of TEMP.
NOTES ARE PROVIDED AT END OF APPENDIX.

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
LAND MOBILITY						
Land Range @ average speed of 25 mph on a hard surface road ORD para. 4.a.(5)(d)	DT-I DT-II	> 250 miles ≥ 300 miles	ATC ATC	FY00 FY03-05	Milestone II Milestone III	
Negotiate slopes - either direction ORD para. 4.a.(5)(f)	ATR DT-I DT-II	60 % 60 % 60 %	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	60%
Operate/steer on side slopes - either direction, including turns ORD para. 4.a.(5)(f)	ATR DT-I DT-II	40 % 40 % 40 %	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	40%
Land acceleration - 0-20 mph ORD para. 4.a.(5)(f)	ATR DT-I DT-II	< 9 sec < 8 sec ≤ 7 sec	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	< 9 sec
Climb vertical wall ORD para. 4.a.(5)(f)	ATR DT-I DT-II	≥ 24 inches ≥ 30 inches ≥ 36 inches	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	24 inches
Center line pivot steer capability ORD para. 4.a.(5)(f)	ATR DT-I DT-II	≤ 1.5 lengths < 1.5 lengths = 1 length	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	1.5 lengths
Gap crossing capability ORD para. 4.a.(5)(f)	ATR DT-I DT-II	7 foot 8 foot 8 foot	ATC ATC ATC	FY96-98 FY00 FY03-05	Milestone II Milestone II Milestone III	7 foot

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
LAND MOBILITY						
Sustainable high speed on hard level surface ORD para. 4.a.(5)(a)	ATR DT-I DT-II	35 mph > 40 mph ≥ 43 mph	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	35 mph
Sustainable low average speed operation ORD para. 4.a.(5)(b)	ATR DT-I DT-II	< 3.0 mph < 3.0 mph ≤ 2.5 mph	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	2-3 mph*
Brake holding capability on longitudinal slope (forward and reverse) ORD para. 4.a.(6)(k)	ATR DT-I DT-II	60% slope 60% slope 60% slope	ATC ATC ATC	FY95 FY00 FY03-05	Milestone II Milestone II Milestone III	pass
Sustained cross country speed ORD para. 4.a.(5) (a)	ATR DT-I DT-II	Permit tactical movement with MBT 30 mph	NOTE 3	FY96-98 FY00 FY03-05	Milestone II Milestone II Milestone III	
Operate in reverse direction ORD para. 4.a.(5)(c)	ATR DT-I DT-II	> 10 mph ≥ 15 mph ≥ 15 mph	ATC ATC ATC	FY96-98 FY00 FY03-05	Milestone II Milestone II Milestone III	10 mph

* ATC considered the requirement met though severe vibration was felt between 2-3 mph and speed was increased to 3.1 mph to complete 10 minute sustained speed requirement.
NOTES ARE PROVIDED AT END OF APPENDIX .

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
WATER MOBILITY						
High water speed in Sea State III (3 foot significant wave height) ORD para. 4.a.(2)(b)	DT-I	20 knots, SSII (2ft. SWH)	AVTB	FY00	Milestone II	NOTE 4
	DT-II	≥ 20 knots, SSIII (3ft. SWH)	AVTB	FY03-05	Milestone III	
Waterborne range at high speed (20 knots) ORD para. 4.a.(2)(k)	DT-I	≥ 50 NM	AVTB	FY00	Milestone II	
	DT-II	≥ 65 NM	AVTB	FY03-05	Milestone III	
Roll stability and self-righting limit (at all weight conditions) ORD para. 4.a.(2)(f)	DT-I	≥ 80 degrees	Analysis*	FY00	Milestone II	
	DT-II	≥ 90 degrees	Analysis*	FY03-05	Milestone III	
Slow water speed and maneuverability (Precision controlled speed (0-6 knots) in a configuration capable of transiting surf zone, small bodies of water, or interfacing with amphibious shipping well deck spaces)** ORD para. 4.a.(2)(c) & 4.a.(2)(h)	DT-I	Up to 4 knots	AVTB	FY00	Milestone II	
	DT-II	Up to 6 knots	AVTB	FY03-05	Milestone III	
Negotiate plunging surf/surf zone and retain full operational capability (vehicle combat loaded - includes both seaward and shoreward movement) ORD para. 4.a.(2)(d)	DT-I	5 feet	AVTB	FY00	Milestone II	NOTE 5
	DT-II	6 feet	AVTB	FY03-05	Milestone III	
Pivot steer ORD para. 4.a.(2)(g)	DT-I	< 1.5 lengths	AVTB	FY00	Milestone II	
	DT-II	= 1 length	AVTB	FY03-05	Milestone III	
Survive High Sea State in combat loaded condition. ORD para. 4.a.(2)(c)	DT-II	SS-V (10ft SWH)	Analysis	FY03-05	Milestone III	NOTE 6
Reverse speed in water to provide sufficient thrust for amphibious ship interface and recovery in Sea State conditions*** ORD para. 4.a.(2)(c)	DT-I	Up to Sea State II (2ft SWH)	AVTB	FY00	Milestone II	
	DT-II	Up to Sea State III (3ft SWH)	AVTB	FY03-05	Milestone III	

*Extreme angle stability and righting response will be evaluated by analysis and extrapolation of data gathered from performance of the AAAV at Sea State III and lower.
**Speed of ship to be determined by doctrine.
***Sufficient reverse thrust for waterborne recovery in sea conditions up to Sea State III.
NOTES ARE PROVIDED AT END OF APPENDIX .

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
RELIABILITY/AVAILABILITY/ MAINTAINABILITY						
Mean Time Between Operational Mission Failure (MTBOMF)	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para. 4.(b)(1)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Availability (A_o)	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para. 4.(b)(2)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Maintenance Ratio (MR)	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para. 4.(b)(3)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Mean Corrective Maintenance Time (MCMT)	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para. 4.(b)(3)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Mean Time Between Maintenance Action (MTBMA)	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para 4.(b)(3)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Durability	DT-I		AVTB/ATC	FY00	Milestone II	
ORD para 4.b.(5)	DT-II	NOTE 7	AVTB/ATC	FY03-05	Milestone III	
Diagnostics Fault Detection Test Fault Isolation Test	DT-I	75% of Specification Requirements	AVTB/ATC	FY00	Milestone II	
False Alarm Rate ORD para 5.b.(2)	DT-II	100% of Specification Requirements	AVTB/ATC	FY03-05	Milestone III	

NOTES ARE PROVIDED AT END OF APPENDIX .

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
INTEROPERABILITY						
Operate in extreme temperature environments (-25° to 125° F) ORD para. 4.a.(6)(n)	DT-II	NOTE 8	Varied	FY03-05	Milestone III	
Operate in varied terrains and climates	DT-I			FY00	Milestone II	
ORD para. 4.a.(1)(b)	DT-II	NOTE 8	NOTE 8	FY03-05	Milestone III	
Position location & heading reference on land	DT-I		ATC	FY00	Milestone II	
ORD para. 4.c.(2)	DT-II	NOTE 9	ATC	FY03-05	Milestone III	
Accurate self navigation at sea	DT-I		AVTB	FY00	Milestone II	
ORD para. 4.c.(2)	DT-II	NOTE 9	AVTB	FY03-05	Milestone III	
Provide secure inter-vehicle and radio frequency transmit/receive communications capability	DT-I		AVTB	FY00	Milestone II	
ORD para. 4.c.(2)	DT-II	NOTE 10	TBD	FY03-05	Milestone III	

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
LOGISTICS/SUPPORTABILITY/ HUMAN FACTORS						
Fit within dimensional constraint - Length x Width x Height (in feet) ORD para. 4.a.(6)(c)	DT-I DT-II FAT	30 x 12 x 10	TBD	FY00 FY03-05 FY07	Milestone II Milestone III Full Rate	
Accommodate and provide access for personnel at all crew and troop stations without leaving the vehicle ORD para. 4.a.(6)(d), 4.c.(1)(d), & 4. c.(4)	DT-I DT-II	5th-95th percentile, MOPP-4 gear	TBD	FY00 FY03-05	Milestone II Milestone III	
Personnel egress via rear ramp of embarked troops ORD para. 4.a.(6)(f)	DT-I DT-II	22 sec. 18 sec.	AVTB AVTB	FY00 FY03-05	Milestone II Milestone III	
Software ORD para. 5.d.(6)	DT-I DT-II	NOTE 11	TBD	FY00 FY03-05	Milestone II Milestone III	
Transportable via commercial and military means Requirement — ORD para: Tie-down provisions 4.a.(6)(h) Compatible with amphibious ships 5.e.(6) Flat-bed/lowboy transportable 5.e.(9) Lift aboard ships 4.a.(6)(g) Compatible with MPF ships 5.e.(7) Rail transportable 5.e.(8) Air transportable (C-5/C-17) 5.e.(10)	DT-I DT-II	Successful load/unload without damage to AAAV or transporter	AVTB, ATC, Air Force Bases	FY00 FY03-05	Milestone II Milestone III	
Combined field of vision for all vehicle stations (horizontal axis) ORD para. 4.a.(6)(o)	DT-I DT-II	360 degrees 360 degrees	ATC ATC	FY00 FY03-05	Milestone II Milestone III	

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
LOGISTICS/SUPPORTABILITY/ HUMAN FACTORS						
Drivers station vision capable of viewing through obscurants and allow high speed operation at night and in adverse weather ORD para. 4.a.(6)(o)	DT-I DT-II	Smoke and land operations only All obscurants, land and water	ATC ATC/ AVTB	FY00 FY03-05	Milestone II Milestone III	
Sufficient space for combat equipped Marines or equivalent cargo ORD para. 4.a.(2)(a)	DT-I DT-II	17 Marines 17 Marines	AVTB AVTB	FY00 FY03-05	Milestone II Milestone III	
Crew composition ORD para. 4.a.(6)(i)	DT-I DT-II	≤ 3 Marines ≤ 3 Marines	AVTB AVTB	FY00 FY03-05	Milestone II Milestone III	
Accommodate and provide access for personnel and weapon station without leaving the vehicle (including reloading under cover) ORD para. 4.a.(6)(d)	DT-I DT-II	5th-95th percentile, MOPP-4 gear	AVTB AVTB	FY00 FY03-05	Milestone II Milestone III	

Critical Technical Parameter	Test Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
FIREPOWER - AAAV(P)						
Firepower employment	DT-I		ATC, Eglin AFB	FY00	Milestone II	
ORD para. 4.a.(3)	DT-II	NOTE 12	ATC	FY03-05	Milestone III	
Vehicle Commander/Gunner vision	DT-I		ATC	FY00	Milestone II	
ORD para. 4.a.(3)(c)	DT-II	NOTE 13	ATC	FY03-05	Milestone III	
Capable of sighting weapon system during reduced light conditions or through battlefield obscurants to effective range of weapon	DT-I	75% of effective range	ATC	FY00	Milestone II	
ORD para. 4.a.(3)(d)	DT-II	100% of effective range	ATC	FY03-05	Milestone III	
Full weapon system operation during land and water operations	DT-I	Low land and water speeds	ATC	FY00	Milestone II	
ORD para. 4.a.(3)(e)	DT-II	High land and water speeds	ATC/ AVTB	FY03-05	Milestone III	

NOTES ARE PROVIDED AT END OF APPENDIX

Critical Technical Parameter	Total Events	Technical Threshold for Each Event	Location	Schedule	Decision Supported	Demonstrated Value
AAAV (C) UNIQUE						
AAAV(C) shall have a weapon system that provides self-defense of the vehicle against dismounted infantry. ORD para. 4.a.(9)(a)	DT-II	Possess a weapon equivalent to a 7.62mm machine-gun capable of a 360 degree field of fire and a maximum range of 1000 m. NOTE 14	ATC	FY04-05	Milestone III	
AAAV(C) shall employ a communications system fielded at the battalion and regimental level with the following interoperability features: Single Channel Ground and Airborne Radio System (VHF SINCGARs) waveform, HF waveform, UHF DAMA tactical satellite system, wide-band data communication system ORD para. 4.a.(9)(d)	DT-II	Comm systems allow the Infantry Commander and designated staff to communicate with higher, adjacent and subordinate forces. NOTE 15	ATC AVTB Camp Pendleton	FY02-05	Milestone III	
The AAAV(C) shall provide 6 multifunctional workstations for the infantry commander and staff consisting of the following: Infantry Commander, Operations Officer, Intelligence Officer, Fire Support Coordinator and Information Systems Representative (S-6). ORD para. 4.a.(9)(c)	DT-I, DT-II	Multifunctional workstations allowing access for commander and staff to radio nets, tactical data systems and communications with other staff members. NOTE 15	ATC AVTB Camp Pendleton	FY02-05	LRIP Milestone III	
The AAAV(C) shall employ the MAGTF Software Baseline (MSBL) system software fielded at the infantry battalion and regimental levels for the following: Operations and Maneuver, Intelligence, Air Support, Automated Fire Support, Mission Planning and Rehearsal, and Logistics ORD para. 4.a.(9)(c)	DT-II	Software applications are accessible, useable, and identical in function to like applications fielded to infantry battalions and regiments. NOTE 15	ATC AVTB Camp Pendleton	FY02-05	LRIP Milestone III	

NOTES ON CRITICAL TECHNICAL PARAMETERS

NOTE 1: NUCLEAR, BIOLOGICAL AND CHEMICAL SURVIVABILITY

As stated in the ORD:

> NBC Survivability. The AAAV, crew, and embarked personnel must be able to survive and operate in an NBC Mission Oriented Protective Posture (MOPP) 4 environment. Protection for the crew and embarked Marines is mandatory. The vehicle also must be able to withstand the corrosive effects of all known chemical warfare hazards and standard decontaminants. Radiological protection will be provided by the ballistic hull and the vehicle will be unaffected by initial neutron and gamma radiation levels below those that will cause human casualties. Protection against electromagnetic pulse produced by nuclear detonations and the accumulation of residual radiation hazards is a threshold requirement. The AAAV shall include an automatic chemical agent and a radiation alarm and measurement system. These systems will be able to measure these effects, both inside and outside the vehicles, providing chemical agent identification that alerts and measures the chemical and radiation effects.

The type of NBC Collective Protection (CP) system (includes environmental control unit) and NBC detection/alarm equipment to be incorporated into the AAAV shall be subject to US Army development efforts. Any NBC systems/components used on the AAAV shall be non-developmental to the DRPM AAA.

The AAAV's NBC survivability criteria has been developed and is specified in references 42 and 43, of Appendix A. Requirements and specifications are not listed herein due to SECRET classification. These requirements shall be detailed in classified Detailed Test Plans (DTP). During the PDRR phase, the vehicle mounted NBC CP system and NBC detection/alarm system shall be tested using threat chemical agent simulants. Stand-alone NBC CP systems and their components, and the stand-alone NBC detection/alarm systems and their components shall be tested using live chemical agents. During the EMD phase, the final versions of the vehicle mounted NBC CP system and the NBC detection/alarm system shall be tested using threat chemical agent simulants. Final versions of stand alone NBC CP systems and their components, and NBC detection/alarm systems and their components shall be tested using live chemical agents. The Government shall approve all live chemical agents used for testing, and all testing shall be accomplished within DoD and environmental guidelines and practices.

The AAAV will be tested to ensure it meets the Nuclear, Biological, and Chemical Contamination Survivability (NBCCS) criteria identified in Department of the Army, Office of the Deputy Chief of Staff for Operations and Plans memorandum, dated 24 Oct 91, DEPARTMENT OF THE ARMY APPROVED QUANTITATIVE NBC CONTAMINATION SURVIVABILITY CRITERIA. During the PDRR phase the AAAV will be tested for compatibility of operation and decontamination, using decontamination simulants, by personnel in full NBC protective ensemble (MOPP 4). AAAV armor/hull samples will be tested for NBCCS hardness and decontaminability using live chemical agents and actual decontaminates. During the EMD phase, personnel in full NBC protective ensemble (MOPP 4) will test the AAAV for compatibility of operation. If the AAAV's armor/hull material changes from that tested during the PDRR phase then samples of the new material will be tested for NBCCS hardness and decontaminability using live chemical agents and actual decontaminates.

The AAAV's Initial Nuclear Weapons Effects (INWE) survivability criteria has been developed and is specified in a classified document listed in Appendix A. Requirements and specifications are not listed herein due to SECRET classification. These requirements shall be detailed in classified DTPs. During the PDRR phase, AAAV components will be screened, analyzed and in some cases tested to determine their Nuclear Hardness. During the EMD phase the AAAV, as a complete system, will be analyzed and tested to verify its hardness against INWE. Testing and evaluation shall be conducted to verify that nuclear hardness is maintained during both production and deployment, and that vulnerabilities are not introduced through changes in components or in manufacturing methods. Parameters that shall be evaluated to determine and/or verify the AAAV's nuclear hardness are: Structural Effects (overpressure), Thermal Effects, Ionizing Radiation Effects (gamma rays and neutron effects), and Electromagnetic Pulse effects, including Transient Radiation Effects (TRE) on Electronics.

NOTE 2: OBSCURATION PROJECTION

Trade-off analyses have been performed for smoke system selection and will be updated in the PDRR phase. Current requirements allow for use of several technologies currently employed on US combat vehicles (such as fog oil-injected exhaust systems and reloadable grenade launchers capable of projecting millimeter wave and multi-spectral smoke).

NOTE 3: SUSTAINED CROSS-COUNTRY SPEED

The requirement for the AAAV system during land operations is to be capable of operating cross-country and in sustained operations with the Main Battle Tank (MBT) of the time frame. Two test parameters will be measured: ability to sustain the required speed for the given terrain, and the capability for the crew and embarked troops to be combat effective after cross-country operations. The evaluation of personnel not succumbing to cross country vibration and shock loading will be in accordance with Military Standards and established US Army mobility evaluation procedures (6-watt ride limiting speed and Fatigue Decreased Proficiency Level in accordance with Mil-Std-1472D). These procedures evaluate operating speeds from zero speed to maximum attainable speed over specified bumps and random terrain courses (measured RMS profiles). Accelerations and absorbed power levels at selected vehicle crew or troop stations are the measured data. During ATR testing, DT-I and DT-II, test measurements will focus first on vehicle speed capability, and secondly on ride quality/power absorption evaluation across the vehicle speed range.

NOTE 4: HIGH WATER SPEED IN SEA STATE III

Over-water vehicle speed and ride quality (fatigue decreased proficiency limits and shock loads) will be measured in the highest attainable sea conditions, up to the Sea State III limit.

Sea conditions of 3-foot significant wave height in a Pierson-Moskowitz random sea spectrum are critical criteria. Each contractor's HTR has already surpassed the speed requirement (scaled for the vehicle size and power available). Test scheduling, prioritization and asset allocation will be directed toward attaining sea conditions during DT-I and DT-II. Test sites exist on the East Coast and West Coast to attain sea conditions.

NOTE 5: NEGOTIATE PLUNGING SURF

Every effort will be made to test at the full Sea State requirement, but the ability to test in the designated sea state condition will be dependent on environmental conditions at the time of testing. Test scheduling, prioritization and asset allocation will be directed toward attaining sea conditions during DT-I and DT-II. Test sites exist on the East Coast and West Coast to attain surf conditions.

NOTE 6: OPERATION IN HEAVY SEAS

The AAAV, in a combat loaded condition shall "survive" in Sea State V (10 ft. significant wave height). To survive, the AAAV, with power, must be able to maintain heading. Without power, it must not capsize for at least 8 hours.

NOTE 7: RELIABILITY, AVAILABILITY, MAINTAINABILITY, AND DURABILITY (RAM-D)

Testing of RAM-D parameters will allow for maturation of components for the EMD phase. Data collected during DT-I/OT-I will be utilized to verify and adjust RAM-D engineering analyses conducted during PDRR. Dedicated reliability growth testing will be conducted in EMD based on test results from DT-I and EOA. Since LRIP vehicles will be delivered over a 24-month period, RAM-D testing conducted early in EMD will impact LRIP vehicle design. In addition, later testing of EMD production representative vehicles during DT-II, IOT&E, and LRIP vehicles during FOT&E will be reflected in full-rate production. A Test, Fix, and Re-test strategy will be utilized to fully mature RAM-D parameters. Table I-1 depicts the verification method for the key RAM-D parameters. Although Operational Availability (Ao) is specified in the ORD, only Inherent Availability (Ai) will be testable (Ao may be estimated). This is due to logistics administration (MPF-Future parts block, Sea-based Logistics stockpile locations, Just-In-Time transit time, etc) that cannot be tested, but is only experienced once the fielded system is at full operational level and tempo. Since durability requirements are very large, conducting a statistically confident test is not economically feasible. Thus analyses, supported by test data, will be utilized to verify these requirements.

Table I-1. RAM-D Requirements

RAM-D Parameter	PDRR	EMD	LRIP
MCMTo ≤ 1.5 hours	Analysis	Analysis	Test
$MCMT_i$ ≤12 hours	Analysis	Analysis	Test
70 hours ≤ MTBOMF 95 hours	Analysis	Analysis	Test
MR ≤ 0.6	Analysis	Analysis	Test
0.80 ≤ Ao ≤ 0.85	Analysis	Analysis	Analysis
MTBMA ≥ 20 hours	Analysis	Analysis	Test
Durability ≥ 600 hours or 6 years, at 0.9 probability	Analysis	Analysis	Analysis

NOTE 8: OPERATE IN VARIED TERRAINS AND EXTREME TEMPERATURE ENVIRONMENTS

Due to limited test assets during the PDRR phase, low temperature/arctic testing and jungle/ tropic environment testing will be accomplished in test chambers or on selected components during DT-I. Scheduling of DT-I test events precludes the utilization of the environmental chambers prior to the MS II review. Chamber testing is planned in the second or third quarter of FY01. Testing in a more operational environment will be conducted during DT-II. Thresholds do not exist for this parameter, except that varied terrain and climates shall not adversely impact operation and maintenance of the vehicle system.

NOTE 9: POSITION LOCATION AND HEADING REFERENCE

The AAAV will utilize a Global Positioning System (GPS) and the current USMC Position Location and Reporting System (PLRS) as a part of a total navigation system, in addition to other proposed navigation means as proposed by the contractor and incorporated in the vehicle design. The following parameters in Table I-2 are tentative conditions for testing that shall be used for both land and water position location and heading test measurement:

Table I-2. Position Location/Heading Test Parameters

Acquisition Phase	Land Position Accuracy	Land Heading Accuracy	Water Position Accuracy	Water Heading Accuracy
PDRR	± 50 feet CEP	± 5 degrees	± 50 feet CEP	± 5 degrees
EMD	*	± 4 degrees	*	± 4 degrees
LRIP	*	± 3 degrees	*	± 3 degrees

*Land and Water Position Accuracy will be established upon information received from the results of PDRR.

Testing to be done by the Government with other systems (PSD vehicle mounted with GPS, PLRS, and magnetic heading devices) will investigate needs and requirements for navigation, position location and driver updates.

NOTE 10: COMMUNICATIONS

Determination of parameters and selection of communication sub-systems shall be dependent on availability of military systems of the time frame (NDI to the Marine Corps). Testing to determine the effect of the composite hull on the ground plane will be accomplished (as required).

NOTE 11: EMBEDDED COMPUTER RESOURCES

COMPUTER SOFTWARE

Determination of parameters and testing of software shall be dependent on the development, selection, and incorporation of specific components in the vehicle. During PDRR, MIL-STD-498 shall be used for the software development with an evolutionary approach consisting for four builds. Formal testing of each build is planned at the conclusion of each subsequent build (e.g., formal testing of build one is planned at the conclusion of build two). Unless otherwise approved by the Government, all software will be developed in Ada in accordance with guidelines established in IEEE Std 990-1987, Recommended Practice for Ada as a Program Design Language, and ANSI/MIL-Std 1815A, Ada Programming Language. The contractor shall establish, control, and maintain a software engineering environment to perform the software engineering effort. As a minimum, this environment shall consist of modern integrated software engineering tools to assist with such things as requirements tracking and traceability, software metrics, and configuration management. A shadow database, consisting of data contained in these tools, shall be available for on-line access via a direct connection with DRPM AAA throughout the software development. Also contained in the engineering environment will be a mock-up configuration of the vehicle electronics to serve as a software integration and testbed. Actual vehicle components or subsystems shall be used to the greatest extent possible. Finally, DRPM AAA shall deploy an Independent Verification, Validation, and Accreditation (IVV&A) team throughout the development process. The Marine Corps Tactical System Support Activity (MCTSSA) is the USMC's software support activity (SSA) and will assume configuration control of the AAAV software once the AAAV is deployed.

COMPUTER RESOURCE RESERVE

Computer resource reserve testing methods and tools will depend on the selected hardware platforms and data busses. It is expected that a combination of software and hardware analyzers shall be utilized to test the resource reserve capacities at peak (full operational) loading. Table I-3 depicts the parameters required for testing during the various acquisition phases.

Table I-3. Computer Resource Reserve

Parameter	PDRR	EMD/LRIP
Computer Processor Throughput	200%[1]	200%
Master Data Bus	500%	500%
Digital Storage	100%[1]	500%
Memory	200%[1]	200%
I/O Channels	60%[1]	60%

[1] Reserve percentages are required at the CSCI level.

NOTE 12: EFFECTIVE FIREPOWER EMPLOYMENT WHILE MOVING AND STATIONARY

Test measurements will be structured in two separate phases, and the results combined to evaluate the ability of the AAAV test vehicles and their weapon systems to meet the requirement. Quantification of these parameters is reflected in the STA and the ORD.

Prior to any lethality being effected on the threat, the AAAV system must possess a level of accuracy and capability to deliver the threat defeating mechanism onto the target at the required range. The ORD states a cumulative probability of hit (P_{Hcum}=0.90 at 1500 meters) accuracy level that will be tested. This accuracy will be determined for the weapon system that is mounted on the host (test) vehicle. Engagement of stationary and moving targets (threat light armored vehicles) from a stationary and moving host vehicle will be tested.

The AAAV weapon system must also be capable of penetrating the equivalent thickness of armor as stated in the STA *(classified)* for the worst case threat vehicle. Ability to meet both the accuracy measure and lethality measure (although conducted separately) will constitute acceptance that the as-mounted weapon system can defeat the threat light armored vehicles of the time frame at the prescribed distance. Failure to meet either measure constitutes unacceptable performance. Detailed test plans will address system level tests to validate any GFE/GFP subsystem performance when integrated into the AAAV (such as weapon systems).

NOTE 13: COMMANDER/GUNNER VISION

The crew station for the Vehicle Commander/Gunner must possess the following attributes:

- Capable of 360° Field of Regard in horizontal plane
- Day/night and all-weather vision (to the effective range of the weapon)
- FOV in the vertical plane equal to or better than weapon system elevation and depression limits (60 degrees elevation, 10 degrees depression over front of vehicle, zero degrees depression over rear of vehicle required)

It is anticipated no growth is needed for these criteria - all delivered vehicle systems will provide inherent compliance.

NOTE 14: SELF-DEFENSE CAPABILITY - AAAV(C)

The requirement for this capability is defined as an anti-personnel, self-defense weapons system. It is expected that a weapon equivalent to a 7.62mm machine gun with a 360^0 field of fire will be employed on the AAAV(C).

NOTE 15: AAAV(C) C4I SUITE CAPABILITY

The AAAV(C) C4I Suite will be an integrated system composed of specified tactical communications equipment, MAGTF C^2 tactical software applications, and selected C^2 systems equipment that will accommodate the identified tactical software applications. Testing will be conducted on the capability of this integrated system to provide the RF and LAN connectivity required, sufficient command/decision support processing to the embarked commander and his staff, and effective and supportable C^2 equipment for the identified tactical applications.

The C4I Suite will be tested using a representative activity loading. The loading will be provided through operational message text via a TOEL. This will ensure that both internal and external communications media will be exercised and that sufficient throughput/bandwidth are available to support a Regimental or Battalion Commander and Staff. Further, this loading will ensure interoperability with external systems/devices, provide necessary input to the software applications resident in the C4I Suite, stimulate interoperability and appropriate command/decision aid processing, and illicit appropriate commander and staff interaction within the AAAV(C) Command Post.

APPENDIX J. LIST OF ACRONYMS

A

A_o	Availability (Operational)
AAA	Advanced Amphibious Assault
AAV	Assault Amphibian Vehicle
AAV7A1	Assault Amphibious Vehicle, Model 7A1
AAV(C)7A1	Assault Amphibious Vehicle, Model 7A1- Command and Control Variant
AAV(P)7A1	Assault Amphibious Vehicle, Model 7A1- Personnel Variant
AAV(R)7A1	Assault Amphibious Vehicle, Model 7A1- Recovery Variant
AAAV	Advanced Amphibious Assault Vehicle
AAAV (P)	AAAV - Personnel Variant
AAAV (C)	AAAV - Command and Control Variant
AAS	Assault Amphibian School
ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum
AFV	Armor Family of Vehicles
AoA	Analysis of Alternatives
AP	Armor Piercing
APB	Acquisition Program Baseline
APC(X)	Armored Personnel Carrier (Experimental)
APG	Aberdeen Proving Ground
ASN (RD&A)	Assistant Secretary of the Navy for Research, Development & Acquisition
ATC	Aberdeen Test Center
ATGM	Anti-Tank Guided Missile
ATR	Automotive Test Rig
ATR(C)	Automotive Test Rig - Command and Control Variant
AVTB/D	Amphibian Vehicle Test Branch/Directorate

B

BDAR	Battle Damage Assessment and Repair
BHT/BH&T	Ballistic Hull and Turret
BRAC	Base Realignment and Closure
BTR/BRDM/BMP	Threat Combat Vehicles

C

C4I	Command, Control, Communications and Computers
CAE	Component Acquisition Executive
CAX	Combined Arms Exercise
CDRL	Contract Data Requirement List

CD/V	Concept Demonstration and Validation Phase
CE	Concept Exploration Phase
CE/D	Concept Exploration/Definition Phase
CJCS	Chairman, Joint Chiefs of Staff
COEA	Cost and Operational Effectiveness Analysis
COI	Critical Operational Issue
CP	Command Post
CPAF	Cost Plus Award Fee Contract
CPX	Command Post Exercise
CTP	Critical Technical Parameters

D

DA	Department of the Army
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DemVal	Demonstration and Validation Phase
DIA	Defense Intelligence Agency
DoD	Department of Defense
DOT&E	Director Operational Test and Evaluation
DOTE (LFT)	Director Operational Test and Evaluation (Live Fire Test)
DRB	Defense Resource Board
DRPM AAA	Direct Reporting Program Manager, Advanced Amphibious Assault
DS&TS	Director Strategic and Tactical Systems
DS&TS(DT)	Director Strategic and Tactical Systems (Developmental Testing)
DSMC	Defense Systems Management College
DT	Developmental Testing
DT-I	Developmental Testing during PDRR Phase
DT-II	Developmental Testing during EMD Phase
DT&E	Developmental Test and Evaluation
DTIC	Defense Technical Information Center
DTP	Detailed Test Plan
DTSE&E	Director Test Systems Engineering and Evaluation
D/V	Demonstration and Validation Phase

E

EAAK	Enhanced Armor Appliqué Kit
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EMD	Engineering and Manufacturing Development Phase
EMT	Executive Management Team
EOA	Early Operational Assessment

F

FAR	Federal Acquisition Regulation
FASA	Federal Acquisition Streamlining Act
FAT	First Article Test
FCT	Foreign Comparative Testing
FD/SC	Failure Definition/Scoring Criteria
FIFV	Future Infantry Fighting Vehicle
FMC	Food and Machinery Corporation
FMF	Fleet Marine Force
FOC	Full Operational Capability
FOF RTCA	Force-on-Force Real-Time Casualty Assessment
FOT&E	Follow-On Operational Test and Evaluation
FRP	Full Rate Production
FSD	Full Scale Development Phase
FUSL	Full Up System Live Fire Test
FY	Fiscal Year

G

GAO	General Accounting Office
GD	General Dynamics
GDAMS	General Dynamics Amphibious Systems
GDLS	General Dynamics Land Systems

H

HE	High Explosive
HTR	Hydrodynamic Test Rig
HWSTD	High Water Speed Technology Demonstrator

I

IER	Independent Evaluation Report
I-IPT	Integrating Integrated Product Team
ILS	Integrated Logistic Support
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPPD	Integrate Product Process Development
IPT	Integrated Product Team
IROAN	Inspect and Repair Only As Necessary

J

JITC	Joint Interoperability Test Command

JROC	Joint Requirements Oversight Counsel
JMEM	Joint Munitions Effectiveness Manual

K

kph	Kilometers per hour
KPP	Key Performance Parameter

L

LAV-25	Light Armored Vehicle (USMC operated)
LCAC	Landing Craft Air Cushion
LER	Loss Exchange Ratio
LF	Live Fire
LFM 0-1	Landing Force Manual 0-1
LFT	Live Fire Test
LFT&E	Live Fire Test and Evaluation
LFT&E WG	Live Fire Test and Evaluation Working Group
LRIP	Low-Rate Initial Production
LVA	Landing Vehicle, Assault
LVT	Landing Vehicle, Tracked
LVT(X)	Landing Vehicle, Tracked (Experimental)

M

$M	Million, Dollars
m	Meters
mm	Millimeters
MAA	Mission Area Analysis
MAGTF	Marine Air Ground Task Force
MAIS	Major Automated Information System
MARCORSYSCOM	Marine Corps Systems Command
MBT	Main Battle Tank
MCAGCC	Marine Corps Air Ground Combat Center
MCCDC	Marine Corps Combat Development Command
MCOTEA	Marine Corps Operational Test and Evaluation Activity
MCRDAC	Marine Corps Research and Development Command
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MNS	Mission Needs Statement
MOE	Measures of Effectiveness
MOP	Measure of Performance
MPS	Maritime Proposition Shipping
mph	Miles per hour
MRV	Mission Role Variant

MSC	Military Sealift Command
M&S	Modeling and Simulation

N

N/A	Not Applicable
NAE	Naval Acquisition Executive
NAS	Naval Air Station
NAVSEA	Naval Sea Systems Command
NBC	Nuclear, Biological, and Chemical
NDI	Non-Developmental Item
NSC	National Security Committee
NTC	National Training Center

O

OA	Operational Assessment
OAT	Office of Advanced Technology
O-IPT	Overarching-Integrated Product Team
OMB	Office of Management and Budget
OMFTS	Operational Maneuver From The Sea
OMFTS/STOM	Operational Maneuver From The Sea / Ship-To-Objective-Maneuver
OMP	Operational Mission Profile
OMS/MP	Operational Mode Summary/Mission Profile
ONR	Office of Naval Research
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Testing
OTA	Operational Test Activity
OT&E	Operational Testing and Evaluation
OTH	Over the Horizon

P

P1	AAAV PDRR Prototype #1
P2	AAAV PDRR Prototype #2
P3	AAAV PDRR Prototype #3
PAT&E	Production Acceptance Test and Evaluation
PDM	Program Decision Memorandum
PDRR	Program Definition and Risk Reduction Phase
PEO	Program Executive Officer
PF/DOS	Production, Fielding/Deployment, Operations and Support Phase
PIP	Product Improvement Program
PM	Program Manager

PMAAV	Program Manager, Assault Amphibian Vehicle
PMO	Program Management Office
PMT	Program Management Team
P_{NP}	Probability of No Penetration
POM	Program Objective Memorandum
PSD	Propulsion System Demonstrator
PVT	Product Verification Testing

R

R&D	Research and Development
R&M	Reliability and Maintainability
RAM	Reliability, Availability, Maintainability
RAM-D	Reliability, Availability, Maintainability and Durability
RAM/RS	Reliability, Availability, Maintainability/Return to Standard
RDT&E	Research, Development, Test & Evaluation Funding
RFP	Request For Proposal
ROC	Required Operational Capability
RPG	Rocket Propelled Grenade

S

SCP	System Concept Paper
SCRE	Stratified Charged Rotary Engine
SECDEF	Secretary of Defense
SEDS	System Engineering Design Schedule
SDR	System Design Review
SLEP	Service Life Extension Program
SOA	Sustained Operations Ashore
SOW	Statement Of Work
SOP	Standard Operating Procedure
SRR	System Requirements Review
SS	Sea State
S/SS	System/Subsystem
STEP	Simulation, Test and Evaluation Process
STU	Special Trials Unit

T

T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TIWG	Test Integration Working Group
TPD	Test Planning Document

U

UDLP	United Defense Limited Partnership
UNDEX	Underwater Explosion
USA	United States Army
USC	United States Code
USD (A&T)	Under Secretary of Defense for Acquisition and Technology
USMC	United States Marine Corps

V

VCJCS	Vice Chairman Joint Chiefs of Staff
VDD	Virtual Design Database
VV&A	Verification/Validation and Accreditation

W

WBS	Work Breakdown Structure
WIPT	Working Level Integrated Product Team
WWII	World War Two

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